TOPOGRAPHIC AND GEOLOGIC SURVEY COMMISSION OF PENNSYLVANIA

REPORT NO. 10

1913

Topographic and Geologic Survey
of Pennsylvania

RICHARD R. HICE, State Geologist

Report No. 10.

The Broad-Top Coal Field

OF

HUNTINGDON, BEDFORD AND FULTON COUNTIES

BY

JAMES H. GARDNER

HARRISBURG, PA.:
WM. STANLEY RAY, STATE PRINTER
1913


VIRTUE
LIBERTY AND
INDEPENDENCE

Topographic and Geologic Survey Commission

GEORGE W. McNEES, CHAIRMAN, Kittanning, Pa.
ANDREW S. McCREATH, Harrisburg, Pa.
EDWARD V. d'INVILLIERS, Philadelphia, Pa.

RICHARD R. HICE, State Geologist, Beaver, Pa.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LETTER OF TRANSMITTAL

To the Members of the Topographic and Geologic Survey Commission:

Sirs:—I herewith submit a manuscript and illustrations giving the results of the Survey of the Broad-Top coal field, by Dr. James H. Gardner. The field work on this survey was done during the summer and fall of 1912, using material and maps which had previously been collected by the survey, adjusted and brought to an uniform scale.

The Broad-Top field has long been recognized as one which should be studied in detail. Prof. Lesley, when State Geologist of the Second Survey, repeatedly called attention to it, but was not able to undertake the work. Owing to changes along commercial lines since the close of the Second Survey it has become more important that this field be thoroughly studied, and it is believed the accompanying report will not only be a great advance in our knowledge of the geology of this area, but will be of great practical value to those interested in the development and mining of coals there found.

It is a greatly to be regretted that a good topographic map was not available as a base on which the geology could be placed. Very considerable search and inquiry was made to discover the map of the late Prof. Lesley, which covered a large portion of the field, but it was impossible to find the same. In the absence of such a map use was made of land maps of the field, which showed the various property lines. On a map of the entire field made up of the several land maps the various mines were carefully located. This gave a large number of accurately located points, for, with very few exceptions, we were able to secure copies of the maps of all mines in the field whether now in active operation or abandoned. Where levels were given on the mine maps they also served to aid in the determination of the structure of the field, so that while natural outcrops were not numerous we were able to secure, over most of the field, a large amount of accurate data.

The history of operations of the field shows many failures. These have been due to a number of causes. In such a field it is imperative, if operations are to be successful, that a good knowledge be had of the structure of the coal bed proposed to be operated, otherwise it will be found, after operations are begun, that it is impossible to

properly continue work. This has been the case in Broad-Top, and some marked failures have been the result of opening on the higher portions of the folds where the coal dipped away in all directions. While the structural map of the Kelly coal, which is part of this report, is recognized as being far from perfect, yet it is believed it will be of very considerable value to the operators in showing the main structural features with sufficient detail to prevent gross errors in mining in the future.

Reference is briefly made in the text to the "coals" of the Pocono Series. It is generally supposed that "fake" mining propositions are confined to metal mining, especially to precious metal mining; but this is by no means the case as is illustrated by the search for coal in the Pocono.

While in the field it was found money was being expended in the search of coal in Sideling Hill. While it is to be regretted that the search for minerals, where experience and the result of geological study show they do not exist in quantities that will justify operation, is at times undertaken without proper technical advice; yet when such work is undertaken under the advice of one posing as a specialist, but who is without standing or reputation among engineers or geologists, and whose chief assets are a persuasive speech and pleasing manner, it is much more to be regretted. It is inconceivable how, with our present knowledge of the Pocono, any man could advise the expenditure of time and money in the search for coal in such localities as Sideling Hill.

The fact that money is being uselessly expended in such quests only emphasizes the necessity of a geological survey with facilities commensurate with the mineral output of the State that it may be at all times in close contact with developments and able to furnish intelligent information to the public.

I feel that this report of Dr. Gardner is one that will be of great service, not only locally, but generally in the State: that it is a credit to the survey and shows, to a very considerable degree, the character of the work that should be undertaken in the other coal fields of the State, and emphasizes the immediate necessity of such work.

Yours respectfully,

RICHARD R. HICE,
State Geologist.

Beaver, Pa., April 10, 1913.

THE BROAD-TOP COALFIELD

JAMES H. GARDNER.

GENERAL STATEMENTS.

The Broad-Top Coalfield of Pennsylvania lies in the south central portion of the State, in Bedford, Fulton and Huntingdon counties. It is east of the Allegheny mountains, and totally isolated from all other coal fields. *a* Geographically the field is intermediate in position as related to the anthracite district of the northeast portion of the State and the bituminous basin, which lies west of the Allegheny mountains. So far as geological structure is concerned, however, the Broad-Top field is by far more closely related to the hard coal basins.

Just as the position of the Broad-Top coalfield is between the anthracite and bituminous basins, so the grade of coal falls into an intermediate classification, known as semi-bituminous. In the Broad-Top region the coal is often called semi-anthracite, as will be discussed in a further chapter.

The Broad-Top coalfield is in the form of a high, dissected tableland, or mesa, known as Broad-Top mountain, which lies between two mountain ranges in one of the northeastward and southwestward elongated basins that characterize the structure and topography of the Appalachian Valley. Northeastward it is continuous with the basin that holds the Northern Anthracite field along the Susquehanna river, including the Wilkes-Barre, Pittston and Scranton districts.

Coal mined from the Broad-Top field goes to eastern markets, being consumed largely for domestic and boiler fuel in cities like Washington, Baltimore, Philadelphia, Jersey City, New York and Boston. There are two railroad companies engaged in hauling Broad-Top coal from the mines to the more important lines; on the west side of the field the line of the Huntingdon and Broad-Top Mountain Railroad and Coal Company connects southward, at Mt. Dallas, with the branch of the Pennsylvania Railroad that southward joins the Baltimore and Ohio at Hyndman and northward joins the main line of

a The reader is here referred to the key-map in the corner of the accompanying geological map, for the exact location of the field with reference to the State and to other coal fields.

the Pennsylvania at Altoona; while the other end of the Huntingdon and Broad-Top road leads northward to the main line of the Pennsylvania at Huntingdon. On the east side of the coal field the 3-foot guage line of the East Broad-Top Railroad Company connects northeastward with the main line of the Pennsylvania Railroad at Mt. Union, where the coal is re-loaded into standard gauge cars.

In 1912 there were seventeen companies operating in the Broad-Top Coalfield.

There are three coal beds mined in the Broad-Top field, being in ascending order, the Fulton, Barnett and Kelly. These are the only beds of commercial importance and the only ones in the field, other than thin beds and local deposits, which are discussed later in this report. The three beds are in the Allegheny Series; the Fulton lies close to the top of the Pottsville; the Barnett about fifty feet above the Fulton, and the Kelly about ninety feet above the Barnett. The intervals between the beds are quite variable in different localities, but the figures as given are not far from the average.

On the north side of the field along Shoups run, on the east side along Trough creek, and northward along Wrays Hill and Rocky Ridge only the Fulton and Barnett beds are mined, for erosion has so reduced the thickness of the measures that the Kelly coal bed is absent from these areas. On the west side of the field, along Six Mile run, Sandy run, Long Branch and Kimbers run, the Kelly is the most important bed; it is the bed chiefly mined in this area.

The Broad-Top coal is of coking character, the Fulton and Kelly beds being better than the Barnett. Only the Fulton and Kelly coals are coked at the present time, and only by companies that mine and coke their own coal and consume the product at their iron furnaces on the Huntingdon and Broad-Top Railroad near the field. The Colonial Iron Company's furnace at Riddlesburg and Joseph E. Thropp's furnaces at Saxton and Mt. Dallas consume coke from their own mines and ovens.

Although the Broad-Top coalfield has been producing high-grade coal in commercial quantities for nearly ninety years, it is surprising how little is known of the real character of the field. Only brief reports and generalized maps have been issued, and these of rather early date. There has been a current belief among many who are only slightly familiar with the field that, due to the comparative small size of the area and the length of time it has been worked, the coal is nearly exhausted; but a careful perusal of this report and the maps that accompany it will, it is believed, convince the reader that such is not the case and that the field is capable of an annual increase in production for many years to come.

PREVIOUS REPORTS.

The first geological report of note, dealing with the Broad-Top coalfield, was by H. D. Rogers in 1858, and included in volume 2, pp. 448 to 465 of his report on "The Geology of Pennsylvania." In this brief and generalized description of the field the author call attention to its location, the geological and stratigraphic relations to the other coal fields of the State, etc., and gives notes on the character and thickness of the coal beds. With the slight developments of the field at that time and the fact that a large portion of the territory was a wilderness, little could be said regarding it and many errors of correlation were unavoidable.

In 1878 the Second Geological Survey of Pennsylvania under Prof. J. P. Lesley, State Geologist, issued a report entitled "Report of Progress in the Juniata District on the Fossil Iron Ore Beds of Middle Pennsylvania, by John H. Dewees, with a report on the Aughwick Valley and East Broad-Top District by C. A. Ashburner;" the same being volume F of the various Survey reports. In this volume the coals of the east side of the Broad-Top field about Robertsdale are mentioned; a general section given with brief notes on the quality of the coals and their value for the manufacture of coke. Accompanying the report are structural cross-sections from Broad-Top Mountain eastward through and beyond Sideling Hill.

In 1882 a report entitled "The Geology of Bedford and Fulton Counties" by J. J. Stevenson was issued as Volume T 2 by the Second Geological Survey of Pennsylvania. With the report were issued colored geological maps of the two counties; on these maps the outline of the southern half of the Broad-Top coalfield was shown on the scale of two miles to one inch. In this volume the portion of the coal field lying in Bedford and Fulton counties is considered. The general structure of the field, the relations of the anticlines and basins, description of the stratigraphy, coal beds, etc., is given, along with a general section of the coal rocks and several analyses of Broad-Top coal.

In 1885 "The Geology of Huntingdon County" was issued as Volume T 3 by the Second Geological Survey of Pennsylvania. This report is edited by J. P. Lesley, and compiled from descriptions and illustrated by maps and sections by I. C. White, using notes by C. A. Ashburner, E. B. Hardin, O. B. Hardin, R. H. Sanders, E. V. d'Invilliers, Franklin Platt and by Lesley himself. In this report, the portion of the Broad-Top coalfield lying in Huntingdon county is described by sections, analyses, photograph of model, drawings, etc. With the report, are included two page maps of topographic sketching by Messrs. Ashburner and Billin in 1875; these maps include the region of Trough Creek and Wray's Hill near Robertsdale, and northward along Rocky Ridge.

PRESENT REPORT.

The field work by the writer of this report was done during the summer and fall of the year 1912. Previous to the beginning of the work on the ground, the various mine maps had been assembled by the State Geologist, Mr. Richard R. Hice, and together with mine locations, etc. were connected and imposed on township property-maps using also in this connection a property map covering the holdings of the Rockhill Iron and Coal Company. Considerable of the map matter for the western portion of the field was obtained from Mr. P. E. Womelsdorff of Phillipsburg, Pa., who has for many years been engaged in engineering work for many of the coal companies in the Broad-Top field.

The base map above mentioned was prepared on a scale of five hundred feet on the ground to one inch on the map. This was the scale for the geologic field work by the writer, mention of which is made in succeeding paragraphs.

The object of this report on the Broad-Top coalfield is to supply a demand by the public for more detailed and authentic information regarding its extent, its value, its development and more especially the possibilities it offers as a future coal supply. Also to furnish those interested in the development of the field with structure sheets, maps of outcrop lines, etc. that will be of service as mining progresses. Manifestly no one mining company or set of companies would ever undertake to issue such information on the field as a whole, and if they should, it would, of course, be held as private information for their own use; hence the value of the work being done by the State is apparent in order to obtain such information for the people generally. Those who might wish to enter this territory as new producers can have at hand, through the State Topographic and Geologic Survey, some authentic and detailed report on the nature of this interesting field.

In making a geologic map of coal outcrops, structural features, etc., on a field scale of five hundred feet to the inch, an original method was devised for facilitating such work. The assembled map referred to in a preceding paragraph was necessarily of large dimensions and yet the necessity of carrying the same in large portions in the field during each day's work soon manifested itself. As this map was on tracing cloth and difficult to unfold and handle with ease in the field; the idea was developed of combining the use of the plane-table and separate portions of the large scale base. To do this a special plane-table sketching-board was designed by the writer and neatly manufactured by Mr. Harry Gibbony, of Everett, Pa. Some notes on the method of its manufacture and use are given here with the possibility that the idea will prove of value to others doing similar work. In brief, the instrument is an elongated plane-table with two

small parallel wooden rollers one on either side; these are placed lengthwise with the board, which may be of any desired width and length, but for lightness should not be over nine inches wide and length to suit the maps. In the present case, it was necessary to have the length about fifty-six inches, but being made of seasoned maple, with minimum thickness the weight is by no means excessive. The board itself is made of cross laminations in order to combine strength with lightness. The rollers are also of light maple and about three quarters of an inch in diameter attached to cross pieces at the end; the wood will take thumb tacks satisfactorily. The board is used with any ordinarily plane-table tripod. The disk for the ordinary plane-table is detached and placed on the under side of the board in order to fit the same on the tripod, and "set up" in the regular way for orienting the board. The map plays across the table forward and backward between the two rollers, the latter being depressed at the sides so as not to elevate the map above the surface of the board. As the map is rolled onto one roller it unrolls from the other so that the geologist can in this manner readily expose any portion of the map desired on which to work. Across the map, a number of north-south, east-west lines are drawn for adjusting the alidade and orienting the map to the proper points of the compass. A very satisfactory alidade for this purpose is the hand Gurley Compass with the two hinged standards.

The geologist finds that the method above outlined is eminently satisfactory for using a detailed base map on a large scale. In the first place he has the advantage of using regular plane-table methods on a connected map; he has the additional advantage of having this map and his full notes always with him in the field. Furthermore he can readily make connected intersections on distant points as well as those near at hand by simply rolling the map and continuing the sight lines. When the final field work is completed, and the map prepared for publication on a much reduced scale, more detail is at hand than can well be used. The numerous mine locations, etc., that were already located on the base map of the Broad-Top mining section enabled detailed locations of the outcrop lines, anticlinal axes, and all that goes to make up necessary features for a geologic map.

The value of doing geologic field work on a large scale base can not be over-estimated as demonstrated in this work. The final reduction eliminates many of the errors that by necessity creep into work on a small scale map.

It was regretted, in the work on the Broad-Top field, that the topography had not been mapped. In 1855 and 1856 Prof. J. P. Lesley made a topographical survey of about two-thirds of the Broad-Top coalfields as a basis for a detailed geological report on the field; but the map was never quite finished, and was lost during the interval

(see foot note bottom p. 59, volume T2 Second Geological Survey of Pennsylvania, 1882) the State Geological Survey was discontinued, previous to the organization of the present survey. Lesley himself said (p. XV in letter of transmittal volume T2, 1882) "My own survey of the coal field, more than twenty years ago, was very elaborate, and my contoured maps of it covered two-thirds of the field." But he withheld the report until the mapping could be completed, which was never done.

Preparing structure contours in the absence of topography is not satisfactory unless a great deal of information is at hand from underground mine levels, etc. Consequently it was found that the only general structure map that could be prepared is on the Kelly coal bed. This is submitted as one of the sheets accompanying this report, and presents, stronger than words, the nature of the synclines and anticlines of the western portion of the Broad-Top field. Structural cross-sections show the character of the field as a whole.

The aneroid barometer was freely used in the field work where practical results could be obtained from its records. Such records were chiefly of value in preparing the surface profiles for the cross-sections. The complex folding of the Broad-Top measures prevents many of the uses of the aneroid in getting stratigraphic measurements. In getting measurements of thicknesses of strata and rock intervals, the method of measuring across at right angles to the strike is the only accurate way for detailed results.

In the preparation of this report, the suggestions of the practical mining men in the field were used and much valuable information was secured in this manner. The best of feeling existed toward the work and hearty co-operation was met with from practically all the operators.

HISTORY OF THE FIELD.

There is probably no authentic record available as to when local mining first began in the Broad-Top field. It is reported that certain Englishmen, who were Tories and not desiring to fight against England in the Revolutionary War, took up their abodes in the Broad-Top mountain region of Bedford and Huntingdon counties; if this be true, it is highly probable that they were the first to make use of coal in that field. In Roger's report on "The Geology of Pennsylvania" he mentions the Amos Figard mine on Six Mile Run as one of the oldest in the field. He states that it was opened sixty years before his visit, which would place the date previous to the year 1800. From his description this mine was located a short distance above the mouth of Shreeve's Run.

Mr. A. J. Black of Broad-Top City states in a letter to the writer that the first mine on the East Broad-Top side was the William ("Bil

PLATE XIV.

Figure 1. Old Charcoal Iron Furnace at Hopewell, built in 1802.

PLATE XIV.

Figure 2. Entrance to the old Philip Barnett Mine at Dudley. Type location of the Barnett coal bed.

lie") Houck mine; this was a country mine that was abandoned and later re-opened, he states, by William Foster for the Rockhill Iron and Coal Company. In the vicinity of Broad-Top City, at the head of Shoups run, the Jesse Cook mine was in operation previous to the building of the Huntingdon and Broad-Top Railroad in 1856.

The real development of the field dates, of course, from the construction of the railroads. The Huntingdon and Broad-Top Railroad was completed from Huntingdon to Hopewell in 1856. The Shoups Run Branch of this road, from Saxton toward Broad-Top City, dates from the same time and commercial shipments began that year. The first coal shipped is reported to have been from the Jesse Cook mine mentioned in the preceding paragraph. Soon afterward the Philip Barnett mine was opened at Dudley. The branches of the Broad-Top road were immediately extended up Six Mile run and Sandy run so that from the year 1856 to 1871, inclusive, the road handled 3,943,232 tons of Broad-Top coal.

In this connection it is interesting to note that the old Hopewell furnace built by Lane and Davis in 1802, and rebuilt in 1830 or 31 was in operation intermittently until about 1885. In connection with the remelting of pig iron from this charcoal furnace, about the year 1846, the furnace company used coke from Broad-Top coal mined from the vicinity of the old Chevington mine on Sandy run.

This coke was used for converting pig iron in an open hearth to pig metal, the coke supplying greater heat in the open than charcoal. The pig metal was then taken to the forge where, by the use of charcoal, it was re-heated for the purpose of making blooms or pieces of iron about twenty inches long and six or seven inches across. The blooms were re-heated and hammered by water-power into bar-iron by the Chaffery process, the bar iron being the product from which wagon-tires, plow-shares, etc. were made.

Coal mining on the East Broad-Top, on the Trough creek side of the field began with the construction of the narrow guage East Broad-Top Railroad from Mt. Union to Robertsdale which was completed in September 1874. This road, though now operated as an independent road by the East Broad-Top Railroad and Coal Company, was formerly under control of the Rockhill Iron and Coal Company. This company owns an iron furnace at Orbisonia, using coal from their Robertsdale mines for the manufacture of coke at the furnace. At the present date the furnace and ovens are not in operation but may be re-started at any time.

Closely related with the first development of the coals of Shoups run is the name of Robert Hare Powell. It is said that he introduced coal from this field in Philadelphia by first carrying samples there in a basket. His mines were located at the present site of Melrose and Minersville below Dudley. The old mining village of Powelton, which

was long ago abandoned and now in ruins, was located about a mile north-east of the station Melrose; it was inconveniently placed on a high hill some distance from the railroad and from operations. About 1882 Powell built the Saxton furnace which is now the property of Joseph E. Thropp who also operates the mines, manufacturing coke at Minersville for use at the furnace.

The name Millers run is in general use for what is also known as Trout run, being the northen tributary of Shoups run that empties near Minersville. This is a stream of clear, cool water that heads on the high Pottsville slopes along the border of Carbon and Todd townships. Its source is in an uninhabited region and it flows perennially; about half a mile above its mouth is placed a dam and intake for the Saxton water supply. The name of this creek is taken from an early settler by the name of Henry Miller who, it is said, came from Lancaster County, Pa., in 1810, for the purpose of mining Broad-Top coal; but finding a suitable location for a farm on a flat-topped hill near the mouth of this creek and game being then abundant in the splendid forests, he decided to live the life of a farmer. This farm was later secured by Powell who built a new residence thereon, which is now standing in good condition. The original house of Henry Miller, which was back of the Powell house, is gone, but the huge stone chimneys still stand as monuments of that early day of Broad-Top history. Mr. C. E. Benson, Civil Engineer of Huntingdon, Pa., states that he has found corner-trees in this section bearing the original marks of 1794.

Broad-Top City is one of the older towns of the Broad-Top coal-field. It is located on the very top of the mountain on the divide between Shoups run and Trough creek. The town bears evidence of having at one time enjoyed a higher relative importance in the mining industry of this field than it bears at the present time. The coal has been mined out in the immediate vicinity of Broad-Top City and these underground workings have exhausted the water supply of all the wells so that the question of water is a serious handicap to the town at the present time. The merchandise and grocery business is the chief industry at present, but being some distance from most of the mines its population is only about five hundred, or about one hundred less than Hopewell, and some seven hundred less than Saxton, which is the largest town bordering the coal field.

The old Broad-Top Mountain House, some two miles west of south from Broad-Top City, is no longer standing, but at one time it was an important stopping point for travelers on the State Road from Riddlesburg eastward to McConnelsburg connections. In Broad-Top City the present Broad-Top Mountain House is in poor condition, but formerly was a resort of some note, succeeding the older house after travel was diverted by way of Broad-Top City.

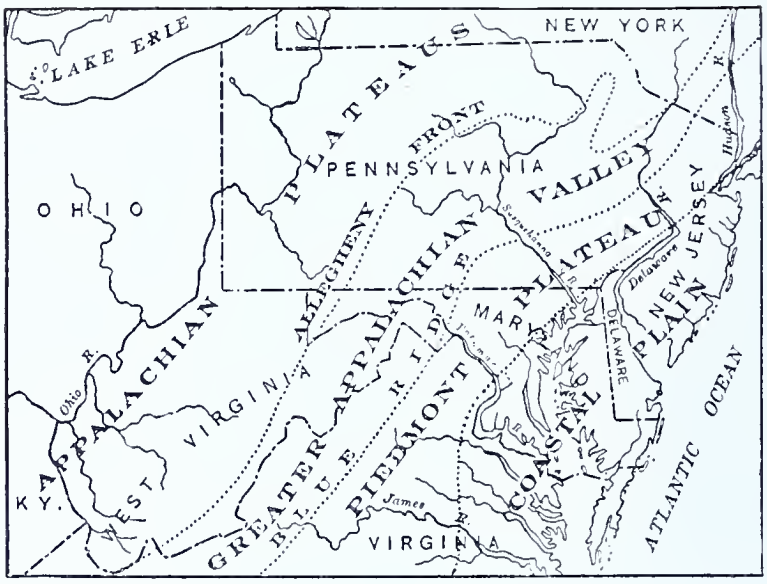


Fig. 1.—Diagram of northern portion of the Appalachian province, showing physiographic divisions.

GENERAL GEOLOGY.

The Broad-Top coalfield is a disconnected portion, or outlier, of the coal measures. In past geological time it was a portion of the great bituminous basin that still covers western Pennsylvania and eastern Ohio, extending southward along the west side of the Appalachian Valley across West Virginia, Virginia, eastern Kentucky and Tennessee to Georgia and Alabama. The anthracite coal measures, like those of the Broad-Top field, are outlying areas of this large and once continuous basin. The result of long erosion has removed many thousand feet of rocks that once extended eastward from the present Allegheny front so that the only areas remaining at present are those patches of coal rocks that have been held in closely folded strata of the Appalachian Valley.

The Appalachian Valley is a physiographic term applied to the belt of north-east, south-west lying mountains and intermediate valleys between the Blue Ridge and the Allegheny Front. (See Plate XV.) Over 20,000 feet of strata extending from the top of the coal measures down to the Trenton limestone have been removed over portions of this province since the close of Permian time.

The Broad-Top coalfield exhibits the highest remaining measures that have escaped denudation in southern Pennsylvania east of the Allegheny Mountains.

The explanation of the existence of the Broad-Top field as a remnant in this zone of extreme folding and erosion, is founded on several conditions. In the first place, it is not to be expected that the removal of rocks in such an area would be brought about uniformly, so that all portions would be finally removed at nearly the same time. The comparative hardness of rocks, their relation to structure, and the adjustment of drainage have all played their parts in the results of erosion; so that in the final analysis, an outlying patch of stratigraphically high rocks, such as are found in Broad-Top Mountain, owes its existence to the interdependent relationships of structure and topography.

The rocks of the Broad-Top field are folded into a series of anticlines and synclines running in a north-east and south-west direction parallel to the larger mountain ridges and valleys of this section of Pennsylvania. A glance at any map of the State will show that structure has had its influence on the location of county boundaries in this general region, the east and west sides of counties being placed along the ridges that naturally form barriers between the inhabited valleys; in this way, some of the counties are elongated to the north-east and south-west but are relatively narrow. In general terms the folding of the rocks in the Broad-Top measures are subordinate to the general depression that lies between Tussey mountain on the west and Jacks mountain on the east. This same synclinorium

continues north and eastward coinciding with the Northern Anthracite basin, so that there are two remnants of coal rocks in this deep fold, both of them resulting from conditions essentially similar. This basin deepens in its northern extension; the top of the Pottsville, for instance, at the deepest point in the Broad-Top field is about 500 feet above sea level whereas in the Northern Anthracite field it lies at a depth of about 1,500 feet below sea level. This general basin is the deepest of the Appalachian Valley in Pennsylvania.

In addition to being included in a profound depression between two mountains, the Broad-Top field has resisted degradation because of its individual structure; the measures dip into the field from all sides giving it the form of a canoe. The coal rocks have been eroded in an irregular fashion at the ends, however, so that the outlines of the field do not conform to its underlying structure; neither does the surface, or profile line correspond to the dips except in a very general way. While the details of structure are taken up under that head further on in this report, these points are mentioned here to show that the field is a remnant of the deepest portion of a local canoe-basin. The soft underlying red shale of the Mauch Chunk has been cut away on all sides so that it now stands as a broad dissected tableland, capped by the harder rocks that compose the coal measures.

The historical geology as recorded in the sedimentation of the coal measures of the Broad-Top field may be commented on briefly. At the base of the Pottsville there is an irregular contact. The base of the lowest Pottsville rocks in this field show that they have been laid down on an uneven surface but the unconformity here is not prominent. The very top of the Mauch Chunk shale shows a tendency to upward transition becoming sandy with thin beds of reddish and gray sandstone.

At some places the base of the Pottsville is of a similar nature as can be seen on the east side of the railroad between Hopewell and Riddlesburg, or on Kimbers run, showing the change in the character of the sediment was gradual from Mauch Chunk into Pottsville time in this region. But in the western part of Pennsylvania, and over the southern extension of the Appalachian coalfield, the Pottsville was deposited after a long period of erosion, so that it rests on rocks low in the Mississippi Series.

In the Broad-Top region deposition rather than erosion occupied most of this time so that the Pottsville followed comparatively closely after the ending of the Mauch Chunk. Thin beds of limestone in the lower portion of the Mauch Chunk have been correlated with the Mountain Limestone which represents in part the Ste. Genevieve and St. Louis, so that the 900 feet of Mauch Chunk above this horizon

falls in all likelihood into the same time interval represented by the Pennington shale of Virginia and Eastern Kentucky and with the Chester of the Mississippi Valley.

The lowest sandstone of the Pottsville in the Broad-Top field usually shows irregular layers of small quartz pebbles, but at places they are entirely absent. At most exposures the sandstones are fine-grained rather than coarse and intensely hard. When pebbles are found in the formation they are rarely in a zone more than six inches thick and are less than one inch in diameter. The Pottsville group as represented in this field correlates with that of Maryland and Central Pennsylvania which David White has shown belongs to a later part of Pottsville time than the lower portion of the Pottsville in the Anthracite field. It seems likely that the slight unconformity shown in the Broad-Top field at the base of what is Upper Pottsville, represents the time interval in which the Lower Pottsville was deposited elsewhere. At one or two places the writer observed pieces of soft, included clay-shale in the sandstone at the base of the formation; these inclusions of shale give local appearance of conglomerate but readily dissolve out leaving an open matrix of porous sandstone.

While some of the sandstones of the Pottsville are very light gray in color, the brownish or ferruginous tint in weathered exposure is seen to contrast with the very light color of the sandstone members of the Allegheny, showing that oxidation was much greater in Pottsville time. A zone of iron carbonate, consisting of kidney-shaped concretions, is found in a bed of shale with thin coal that underlies the Homewood sandstone at the top of the formation. Thin coal streaks in the Pottsville here testify to the fact that the great coal forming period that was to follow had begun its initial development.

During the Allegheny, or Lower Productive period of time, the coal beds of the Broad-Top field from the Gordon coal to the Kelly inclusive were formed. Between each of the coal beds are strata and sandstone with local occurrences of thin limestone beneath the Dudley and Kelly beds. Between the Fulton and Barnett beds on the southwest side of the field, and locally in the central and eastern portions, sandstones show local conglomerate phases; the pebbles are about the size of peas and consist of white, opaque quartz of sub-angular outlines, though thoroughly water worn. Beneath the Kelly bed on the north side of the field, beyond Six Mile run, and over the eastern portion of the field, a massive sandstone carries small white quartz pebbles. It has been confused with the Mahoning sandstone that lies above the Kelly and also confused with the Pottsville as pointed out under the subject of structure. It may correspond to the Butler sandstone. The Mahoning sandstone carries small pebbles locally at the base, as on Sandy run, and also toward the top as may be seen between Six Mile run and Shoups run. These pebbly sandstones in-

dicate that considerable currents were necessary to carry them to the point of deposition; evidences of currents are otherwise present in the form of cross-bedding. The lenticular and variable character of the members indicate that stream currents were responsible for their sedimentation, and it is probable that the whole of coal measures time in this section was characterized by fresh-water deposits.

The fresh-water rocks of the Broad-Top field seem to include also the thin, local beds of limestone; these beds are of the fine-grained, hard, bluish-gray variety that contain no traces of fossils such as are nearly always evident on close inspection of a marine or brackish-water limestone.

The Conemaugh rocks consist of sandstone, shale and thin beds of coal such as are found in the Lower Barren Series generally, and similar conditions of deposition prevailed through the succeeding coal measures; an exception to this statement is found in the deposit of limonite above the Pittsburgh (?) coal which probably represents a considerable period of oxidation at a time when deposition was interrupted.

After the close of Permian time the Appalachian field was elevated sufficiently to interrupt deposition. At this time it is probable that the slow processes of folding began that in time brought about Appalachian structure. The extreme folding of the sedimentary rocks of the Appalachian Valley need not be explained by supposing a sudden compression attending a catastrophe. On the other hand it cannot be held that the initial stages of deformation began early in the Paleozoic and were carried along at recurrent intervals throughout the deposition of the series. The details of correlation of the coal measures in the Broad-Top field, which lies in the very central portion of the folded area, with the beds of the bituminous field west of the Allegheny front, are facts against the idea of independent basins developed previous to the ending of Carboniferous time.

As shown by Willis in his admirable work on the "Mechanics of Appalachian Structure," (U. S. Geological Survey, Thirteenth Annual Report Part 2, pp. 217-282) there are two great problems to be considered in relation to the uplift and folding of the rocks across the Appalachian Valley; one being the problem of general uplift; the other is the lesser problem of zonal compression. Now if the stratigraphy of the Appalachian Valley correlates in detail with the bituminous fields west of the Allegheny front, as is shown to be the case not only in the Broad-Top region but also in the folded coal measures of Maryland, then we are forced to conclude that the general uplift and the horizontal compression both post-date the Carboniferous and were possibly synchronous. The lateral pressure that was necessary to crumple the measures has been explained by adjustment of the earths crust, or the principle of isostacy, as related

to general contraction. Sediment from the continental, or land, areas is at all times being removed to the seas so that a balance is brought about from the transfer of loads, one portion of the earths crust rising to compensate for another portion depressed, the outer rocks of the earth, or lithosphere, resting upon a fluid interior or centrosphere.

As stated by Willis, "Appalachian folding began at a time when deposition caused isostatic adjustment and that adjustment localized and directed contraction." From the great mass of sediment transferred from land to sea, a pressure was set up landward, the continent in Carboniferous time being to the southeast, stretching away from the Blue Ridge, and the sea extending to the northwest. Willis states that "whatever the resistence opposed to it(the force of isostatic adjustment and of contraction), this pressure would gather until it was just greater; then, without violence, without shock, the opposed masses would yield." "Folding in this zone (The Appalachian Zone) ceased altogether when epeirogenic deformation transferred the scene of deposition to another sea."

While we know that the general uplift of the Appalachian belt has continued with interruptions, through periods of peneplation and subsidence, to the present time, thus elevating the deposits of the Coastal Plains, there is no evidence that lateral compression has been folding the strata of the Appalachian Valley during this interval. It is more likely that this folding began and culminated at the close of the Permian; then began the adjustment of stream drainage and the long subsequent period of erosion.

The streams of the Appalachian Valley in Eastern Pennsylvania tend to follow the synclinal troughs that lie between anticlinal ridges; at various points, however, they are diverted from this course and suddenly cut across anticlines through steep gaps only to follow for some distance another parallel valley; in this manner they finally find their way out of the zone of folding. It is but natural that in the initial stages of drainage the streams should have followed the synclinal troughs but the matter of crossing the ridges involves the various points of adjustment, such as "stream piracy", wherein streams are extended by erosion at their heads so as to tap or capture other streams. The writer believes, however, from the manner in which small streams are influenced in crossing the folds in the Broad-Top field, that primary structure has played a very important part in determining the points at which the streams cross the axes of anticlines. It is true on a small scale, and appears to be true in many cases or a much larger scale, that the streams cross where the axes are depressed, or in other words opposite the bottom of the canoe-basins. The anticlines rise and fall along the strike line, just as the basins canoe up and down and in this manner the original cross-

drainage was controlled to a very important extent; subsequently, the relief as dependent on hardness and softness of rocks in erosion has greatly controlled the location of many of the smaller branches. A reference to the cross-section, (G——H,) presented with this report, made lengthwise with the folding of the Broad-Top measures will show the harmony between depressions and cross drainage. Shoups run, Six Mile run and the two branches of Sandy run flow across longitudinal depressions in the folding. The location of Kimbers run, as shown by the profile, is more the result of topography produced by recession of a dip-slope, the slope itself, however, being produced by a rise along the strike.

That erosion has gone on continuously in the Broad-Top region is testified to by the almost total absence of Pleistocene deposits. There are very low and narrow flood-plains above the present streams within the field and on these rest sub-angular bowlders of sedimentary rocks carried down by torrential currents of present age. There is a complete absence of higher terracing and deposition of gravel deposits above the streams that head in Broad-Top Mountain.

STRATIGRAPHY.

The stratigraphic column of rocks in the Broad-Top field from the base of the Pottsville up to the highest beds as exposed on Round Knob, is represented by the following general section. This section is reproduced in columnar form and published as Plate No. III; it is compiled from details of intervals in different portions of the field so as to include all the exposed coal beds.

GENERAL SECTION.

(Reads down in natural order.)

		Ft.	In.
DUNKARD (?)			
60	Sandstone (Waynesburg?) massive, soft, coarse, cross-bedded dark-gray, with patches of pink and red; contains many casts of fossil wood. Caps Round Knob,	90	
MONONGAHELA.			
59	Concealed. Probably shale and coarse, soft sandstone, ..	150	
58	Shale, dark-colored, clay, ...	30	
57	Shale, black, carbonaceous, ...	?	
56	Sandstone, massive, coarse-grained, micaceous, dark-gray but weathers yellowish to brown. Caps Rogers Knob,	40	
55	Concealed, ...	25	
54	Limestone, bluish, fine-grained, hard, ...	0	10
53	Concealed, ...	55	
52	Limonite, ...	?	
51	Concealed, ...	30	
50	Shale, dark-colored, ...	15	
49	Coal, Rogers bed. Pittsburgh (?), ...	4	
CONEMAUGH.			
48	Concealed, ...	20	
47	Sandstone, massive, gray, coarse-grained, contains pea-sized pebbles of white quartz and inclusions of shale. Weathers in small blocks showing lense-shaped cavities,	50	
46	Concealed, ...	55	
45	Sandstone, greenish-gray, flaggy, ...	15	
44	Concealed, ...	40	
43	Shale, black, bituminous, ...	3	
42	Concealed, largely shale, ...	80	
41	Coal horizon of McCue basin bed, ...		
40	Concealed. Sandstone and greenish-gray shale, largely,	155	
39	Coal, Mosquito-Hollow bed, ...	0	10
38	Shale, greenish-gray, sandy, ...	30	
37	Coal, Phipps bed, ...	2	
36	Shale, ...	10	
35	Sandstone, greenish-gray or brown, ...	20	
34	Coal, Speer bed (Mahoning), ...	1	3
33	Sandstone, greenish-gray or brown, ...	40	
32	Shale, ...	10	
ALLEGHENY.			
31	Coal, Kelly bed (Upper Freeport), ...	4	
30	Clay and shale, ...	10	
29	Sandstone, light-gray; contains pea-sized pebbles of white quartz, ...	50	
28	Shale and sandstone, ...	50	
27	Sandstone, hard brown, ...	18	
26	Concealed, ...	20	

		Ft.	In.
25	Coal and bone, Dudley (Lower Freeport),	3	
24	Sandstone, brown, and shale,	15	
23	Sandstone, hard, gray, fine-grained,	46	
22	Shale, dark bituminous, sandy,	10	
21	Coal (Barnettstown or Upper Kittanning),	1	4
20	Shale, and thin sandstone,	9	
19	Coal (Probably belongs to Upper Kittanning zone with next bed above),		8
18	Shale, dark, bituminous, sandy,	40	
17	Coal, Twin bed (Middle Kittanning?),	1	
16	Shale, dark, bituminous, sandy,	12	
15	Coal, Barnett bed (Lower Kittanning),	3	
14	Shale, dark, bituminous, sandy, with horizon of Scott shaft coal near center,	30	
13	Coal, Fulton bed (Clarion),	5	
12	Clay and dark sandy bituminous shale,	20	
11	Coal, Gordon bed (Brookville),	1	
10	Shale, dark, bituminous sandy,	30	
POTTSVILLE.			
9	Sandstone (Homewood) hard, medium-grained, micaceous, gray, but weathers reddish-brown; contains stems of Calamites,	45	
8	Shale, bituminous with streaks of coal; (Mt. Savage or Mercer horizon?),	2	
7	Shale, bituminous, carrying kidney-shaped siderite concretions in upper portions,	30	
6	Sandstone (Conoquenessing?) hard, medium-grained, micaceous, gray but weathers reddish-brown,	30	
5	Shale, carbonaceous with streaks of coal (Sharon?),	1	
4	Sandstone, brown, gray and greenish-gray,	34	
3	Concealed, probably sandstone,	25	
2	Sandstone, gray, containing white quartz pebbles less than one inch in diameter,	10	
1	Sandstone similar to above layer with thin conglomerate lenses,	15	
	Unconformity,		
	Mauch Chunk Red Shale,		

Before taking up further the details of variation of the different intervals of the rocks in special districts, the writer wishes to briefly discuss the general section making cross-reference to certain beds by corresponding numbers.

In the preceding section, rocks from No. 1 up to No. 9 inclusive were measured on Sandy run near Hopewell; No. 10 to 15 inclusive at Gordon Mines on Shoups run; No. 16 to 27 inclusive in the vicinity of Barnettstown and Dudley; No. 17 to 31 inclusive in the high hills of Dudley; No. 32 to 48 inclusive on the north side of Round Knob; No. 49 to 57 inclusive on Rogers Knob north of Mt. Equity mines; No. 58 to 60 inclusive, at top of Round Knob.

Additional sections will show that the different intervals between the coal beds vary greatly in the nature of the strata. Between the Fulton and Barnett coal beds, for instance, the variation is notable in the thickness of the interval as well as the character of the rocks; on Shoups run it is composed of dark, bituminous shale that has been called the Powelton shale; but on portions of Six Mile run and Sandy run and on the east side of the field, this interval is made up largely of sandstone and fine, quartz conglomerate.

PLATE XVI.

Pottsville sandstone near Coalmont, showing its resistent character and freedom from pebbles.

The deposition of shale on the north side of the Broad-Top field prevailed from the close of the Pottsville up to the time that massive beds of sand came in producing bed No. 23 of the section. It is quite probable that beds 23 and 24 represent the Freeport sandstone of Western Pennsylvania. This sandstone in the Broad-Top field is rather local in its development and appears to be totally absent except in the territory extending from the upper portion of Six Mile run northward to Dudley.

The pebbly sandstone, or No. 29 of the preceding section, likely corresponds to the Butler sandstone. This member has been the source of considerable confusion in previous reports on Broad-Top geology.

On the north side of the field, it has been considered Mahoning and along the Broad-Top anticline was mapped for Pottsville in the report on Bedford and Fulton counties; in this manner the East Broad-Top beds were previously considered to be entirely disconnected from those on the west side by an intermediate anticlinal ridge of Pottsville conglomerate. But the resistent sandstone that has held the surface over this low field is far above the Pottsville, as is now proven not only by the structural geology but by drill-holes and underground mine workings.

One of the main causes of error in the correlation of this member has been the fact that it is totally absent along Six Mile run below North Point, and is insignificant along Sandy run. But it is generally represented over the east and north sides of the field being especially prominent in the vicinity of Dudley and along the upper portion of Six Mile run and Shreeves run; also about Robertsdale and Woodvale where it has been considered Mahoning.

The Mahoning sandstone is everywhere found over the Kelly coal bed in the form of massive ledges or broken into large angular blocks. It is brown-colored on fresh fracture as well as on weathered surfaces everywhere except along the upper portion of Sandy run where it weathers light-gray toward the base and contains small quartz pebbles, resembling No. 29 of the general section. Northward from Six Mile run, the Mahoning is typically massive and brown; it contains irregular zones of small pebbles over this area. But pebbles in the Mahoning are the exception rather than the rule, and it is seldom of a light color either when freshly broken or weathered. The Butler (No. 29) however, is always light-colored and invariably contains coarse, white, sand grains or small, white, opaque, quarts pebbles.

The sandstone and shale members of the Conemaugh show a tendency to greenish-gay in color possibly due to iron carbonate. No. 47 of the section, beneath the Pittsburgh bed, may correspond to the Morgantown sandstone. It is exposed in the higher Knobs bordering Six Mile run and in the high ridge south of Sandy run. This sand-

stone contains small quartz pebbles but has a characteristic porous appearance on weathering due to small inclusions of shale.

The identification of the Monongahela and Dunkard series is not positive since no paleontologic evidence could be secured on this point. But the resemblance of the structure of the Rogers coal to the Pittsburgh bed has led former geologists to correlate it with the Pittsburgh and the writer has failed to secure sufficient evidence to justify an alteration of this view. Ashley found that the interval between the Upper Freeport bed and the Pittsburgh bed thickens across the east side of the bituminous basin in a manner that indicates the same interval in the Broad-Top field would be, with the same uniform thickening, about 900 feet; the interval to the Rogers coal is 560 feet in the general section given herewith. This interval practically agrees with the thickness of the same stratigraphic interval in northern Maryland near the Pennsylvania line and with certain sections on the east side of the bituminous basin. Inasmuch as the distance from the Broad-Top field across to the bituminous field is more than fifty miles, it is questionable whether the thickness of the Conemaugh west of the Allegheny mountain should control correlation at that distance; especially since it is known that the same interval varies greatly from point to point in the Appalachian field generally.

A massive cross-bedded, gray sandstone dappled with pink and red caps Round Knob 345 feet above the Pittsburgh (?) bed. This member contrasts lithologically with all beds below and is provisionally correlated with the Waynesburg sandstone of the Dunkard period. The thickness of rocks between the bottom of this sandstone and the Pittsburgh (?) bed is about normal for the Monongahela. Furthermore the nature of this highest rock in the Broad-Top field is similar to the typical Waynesburg in several respects thus making the correlation, everything considered, probable.

A logical method of describing the details of stratigraphy in different portions of the field is to present a general section for respective areas and to comment on the variations. In the following paragraphs this is done for Shoups run, Six Mile run, Sandy run and East Broad-Top field about Robertsdale and Woodvale.

The following is a general section on Shoups run, compiled to apply to the rocks along the run and northward; it does not include the higher rocks that hold the Kelly coal southward in the high divide toward Six Mile run, the detail of which is given in the general section.

GENERAL SECTION ON SHOUPS RUN.

ALLEGHENY (Not complete).

		Ft.	In.
24	Sandstone, massive, pebbly (Butler),	35	
23	Concealed,	40	
22	Sandstone and clay shale,	40	
21	Coal and bone, Dudley bed,	4	
20	Sandstone and shale,	15	

		Ft.	In.
19	Sandstone, massive, gray, cross-bedded at base, ...	70	
18	Shale, sandy, ...	10	
17	Coal, (Barnettstown), ...	1	6
16	Shale (Barnettstown), ...	6	
15	Coal (Barnettstown), ...	0	8
14	Shale, dark, sandy, weathers gray, ...	40	
13	Coal, twin bed, ...	2	
12	Shale, dark, sandy, weathers gray, ...	12	
11	Coal, Barnett bed, ...	3	
10	Shale, dark, sandy, weathers gray, ...	50	
9	Coal, Fulton bed, ...	5	
8	Shale, dark, sandy, weathers gray, ...	20	
7	Coal, Gordon bed, ...	1	
6	Shale, dark, sandy, ...	30	
POTTSVILLE.			
5	Sandstone, massive, hard, grayish white, flaggy at top, .	50	
4	Shale, bituminous and coal streak, ...	2	
3	Shale, and greenish sandstone, ...	20	
2	Sandstone, massive, hard, gray (Connoquenessing), ...	20	
1	Concealed, ...		

In the preceding section it will be noted that the nature of the sedimentation between the different coal beds, from the top of the Pottsville up to No. 18, is that of dark sandy shale that weathers gray in color. The prominence of these beds of shale along Shoups run near old Powelton led to their being designated the "Powelton shales" in the report on Huntingdon County (Volume T 3 p. 61); the name was used, however, to apply more specifically to the shale between the Fulton and Barnett coal beds. At the old openings of the New York Coal Company, south of Coalmont, the interval between the Fulton and Barnett was found to consist of massive sandstone; this fact shows the great variation in the nature of the rocks from point to point in comparatively short distances.

So far as known the two thin coal beds, No. 15 and No. 17, that are exposed around the rim of the hill on the east side of Shoups run between Dudley and Barnettstown, are found only in this vicinity; at other places they are represented by beds of carbonaceous shale. But it may be truly said that there are remarkably few exposures of the rocks at this horizon in the entire Broad-Top field.

The massive sandstone, No. 19, was previously mentioned as being in all probability a representative of the Freeport sandstone; it is represented by beds 23 and 24 of the general section. The Dudley coal bed is erratic in its occurrence in the Broad-Top field and is never found of workable quality; at many places it is entirely absent. The irregular occurrence of the Dudley coal is consistent with the nature of the Lower Freeport coal in the bituminous basin, with which it is for other reasons correlated.

The massive sandstone that carries small quartz pebbles, No. 24 of the Shoups Run section, has been previously mentioned in relation to its correlation with the Butler sandstone. This sandstone is

typically exposed on the hills north of Dudley and southward on the Coaldale road toward the Bedford county line. It weathers out into large angular blocks that lie on steep hill sides below the level of its outcrop. (See Plate XVII Fig. No. 1 this report.) It has been called the "top rock" in the vicinity of Broad-Top City and Robertsdale where it lies nearer the Barnett bed and has there been erroneously identified as the Mahoning sandstone.

In the early days of mining near Broad-Top City, when the "top rock" of that vicinity was considered to be Mahoning, the one bed being mined at Broad-Top City was thought to lie above the Fulton and Barnett beds as known at Dudley and was called the Cook bed; it was thought to be the same as the Kelly bed of Six Mile Run, but as mining progressed it was later proven that the coal bed at Broad-Top City was the same as the Fulton bed at Dudley, being 50 feet below the Barnett bed instead of 100 feet above it. Later the Barnett bed was opened at Broad-Top City and the whole situation was cleared. But the idea continued to prevail that the pebbly sandstone above the Barnett at Broad-Top City is Mahoning, and this idea was carried on eastward into the East Broad-Top basin about Robertsdale and Woodvale.

In reality the name Cook, as taken from the old Jesse Cook mine at the head of Shoups run, should take precedent over the name Fulton which was later applied to the same bed at Dudley.

When a bed was discovered beneath the bed at the old Philip Barnett mine at Dudley (or Barnett bed) it was thought to be an entirely new bed and was named for the engineer, John Fulton, of the Cambria Iron Company. But the name Cook was older and should have been used instead of Fulton when the two beds proved to be identical. However, the name Fulton has come to be used for the bed over the whole Broad-Top field. The name Cook was rejected, naturally, after it had come to be confused with both the Kelly and the Fulton. It is rarely heard at the present time and should now be dropped entirely. Now and then one of the older residents will use the expression "Cook or Kelly" and again another will be heard to say "Cook or Fulton." In this connection the writer wishes to quote from the report on Huntingdon County issued as Volume T 3 of the Second Geological Survey of Pennsylvania in 1885. Pages 63 and 64,

"The idea that the Cook bed near Broad-Top City is the Kelly bed and far above the Barnett is still held by some of the old miners in Bedford County; but in Huntingdon County there are no coal operators, and scarcely any miners, who do not now identify the Cook with the Fulton.

"The honor of demonstrating the identity of the Cook and Fulton beds belongs to Mr. W. H. Sweet, of Dudley, superintendent of the

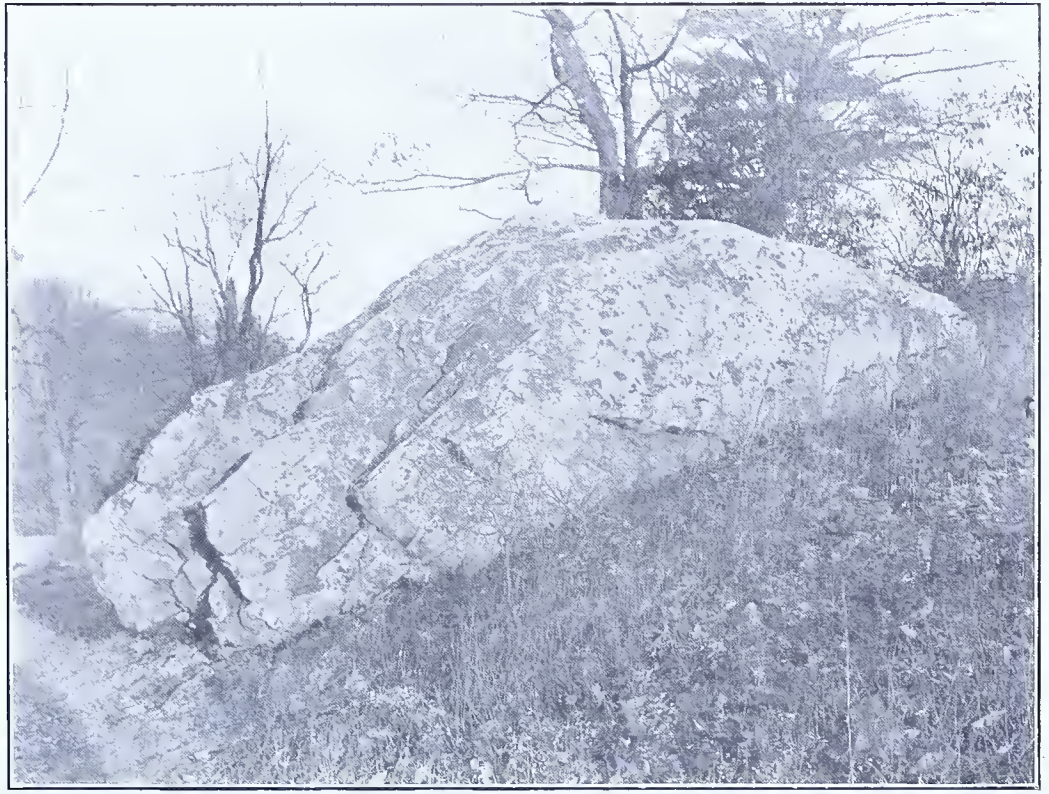


PLATE XVII.

Figure 1. Massive bowlder of Butler sandstone on hillside north of Dudley. This member invariably weathers to a very light gray color

PLATE XVII.

Figure 2. North-slope of Six Mile Run below Defiance, showing angular blocks of Mahoning Sandstone. Outcrops are obscured in this manner throughout the Broad-Top field.

Ocean Mines, who, from a study of the different coal openings between Broad-Top City and Dudley, had already arrived at the conclusion that the two coals found above Dudley were the same as the two found below Dudley. The demonstration of the correctness of this view was the result of a practical question arising in the workings of the Howe mine above Dudley.

This mine was operated on a bed which lay 50 or 60 feet above the Cook and which Mr. Sweet claimed was identical with the Barnett. The original Barnett bed had been mined from a slope at Dudley far up the southeast rise toward the Howe mine. Mr. Sweet, the "mine boss" at the Howe works, proposed to cut a "dip heading" down to the old Blair works on the Barnett to establish drainage, although the Howe coal was commonly supposed to lie at least 100 feet above the Barnett. Mr. Sweet, however, was unmoved by predictions of failure, and putting a force of men to work on the "dip heading" was eventually rewarded by seeing them dig into the old Blair mine, on the acknowledged Barnett bed."

GENERAL SECTION ON SIX MILE RUN, FROM THE POTTSVILLE TO THE MAHONING SANDSTONE.

		Ft.	In.
21	Mahoning sandstone, brown, massive at base, thin bedded toward the top,	20	
20	Coal, Speer bed,	1	
19	Shale and clay,	3	
18	Mahoning sandstone, brown massive,	30	
17	Shale and greenish-gray sandstone,	15	
16	Coal, Kelly bed,	4	
15	Clay and shale,	5	
14	Sandstone, fine-grained, dense greenish-gray,	6	
13	Shale, sandy, gray and brown sandstone,	25	
12	Coal, Dudley bed,	1	3
11	Sandstone, massive, brown, hard fine-grained,	25	
10	Sandstone, shaly,	10	
9	Coal, Twin bed,	1	2
8	Shale and shaly sandstone,	20	
7	Shale and bone coal,	0	6
6	Coal, Barnett bed,	3	
5	Sandstone, thin, brown, and shale,	40	
4	Coal, Fulton bed,	4	
3	Shale and thin sandstone,	25	
2	Coal, Gordon bed,	0	8
1	Pottsville group,	250	

While the strata on Six Mile run are quite variable from point to point, the preceding section is fairly representative. Exposures are very few in number and limited in extent toward the head of the stream and since no mining is being done in that region, little is known of the details.

The Gordon coal, No. 2 of the section, was not seen by the writer but is given in a report made years ago when the lower portion of the section was better exposed just above Riddlesburg; it is mentioned in Volume T 2 p. 65 and the statement made that this bed was not seen elsewhere.

The interval between the Fulton and Barnett beds and the character of the rocks are exceedingly variable on Six Mile run. At the old Cunard or Wigton shaft at the upper side of Coaldale the interval between the two beds was found to be less than 10 feet, at places, consisting of shale and thin sandstone; while less than a mile distant at the old Maguire and Givens shaft (Scott shaft) this interval is 70 feet. A drawing that shows the detail of the Maguire and Givens shaft made by Fulton in 1863 was exhibited to the writer by Mr. John Langdon; it is interesting to note that this section shows a bed of slate and some coal about 25 feet above the Fulton, being the only place known where such a bed has been reported in the entire Broad-Top field.

Above North Point a bed of hard quartz conglomerate lies between the Fulton and Barnett beds, about 30 feet below the Barnett; this member shows in the creek at the first point where the Woodvale road crosses Six Mile run above North Point; it is an irregular, cross-bedded deposit, probably representing an old stream channel since it is very local and noted only at a few points in the field.

In a drill-hole by the Rock Hill Iron and Coal Company near Robertsdale a similar rock in this position gave great difficulty in cutting with the diamond drill. It is highly probable that this conglomerate layer occurs locally elsewhere in the east side of the field where it might readily be confused with the Pottsville. On Lower Sandy run and on Kimbers run coarse sandstone with small pebbles are found at this horizon.

The massive sandstone bed, No. 11 of the Six Mile Run section is probably the Freeport sandstone. It is absent from the section in the vicinity of Coaldale and is represented by sandy shale along the incline that leads up to Illinois No. 4 opening. It occurs again, however, at the tipple of the Mt. Equity mine and blocks of it are found along the hillside above the Barnett horizon east of North Point.

The Dudley coal bed is irregular on Six Mile run and is absent at many places. It is liable to be found, however, at unexpected points and lead to considerable confusion among prospectors who have not been accustomed to it in their own locality. It is never workable but often tempts prospecting. It was recently cut in the workings at the Duval slope when it was at first thought to be the Twin coal above the Barnett; at other points it has been considered Kelly. It may be found as a mixture of hard bone-coal, shale, and streaks of good coal or again as a thin bed of clean coal. This bed was cut and prospected below the Kelly opening on the plane leading to Illinois No. 4 mine. At the latter point the sandstone, No. 13, of the preceding section has thinned down to thin sandstone and sandy shale. It seems probable that the mixture of coal and shale that was aban-

PLATE XVIII.

Figure 1. Outcrop of Mahoning Sandstone on Six Mile Run at the Rock-bar Mine. Note entry to slope on Kelly coal.

PLATE XVIII.

Figure 2. The Mahoning Sandstone near Defiance, showing the contact of the top, thin-bedded portion, with the massive bed at the base. This sandstone weathers brown in contrast to the Butler. See Figure 6.

doned at Delaware mine No. 3 and thought to be Kelly is the Dudley, though manifestly the exposures in that vicinity are exceedingly scarce so that the relation of the beds to the underlying Barnett could not be determined with certainty.

The Butler sandstone is likely represented at interval No. 13 of the preceding section. This sandstone is absent along the lower portion of Six Mile run. But toward the head of Six mile run it reappears and there contains small, white, opaque, quartz pebbles. Blocks of this white conglomerate are strewn over the surface of the ground beneath the horizon of the Kelly coal bed along Widow run, Wisdom run and along Shreeves run near Finleyville. South of Finleyville this conglomerate lies at the surface at points where the Kelly coal is eroded away. It can be seen about Round Knob where its pebbly character is especially prominent.

The confusion of this pebbly sandstone beneath the Kelly coal with the pebbly phases of the Mahoning that lies above the Kelly is a most common thing among the prospectors of the Broad-Top field; this is most natural, however, since the pebbly sandstone, beneath the Kelly is absent along Lower Six Mile run, Sandy run and Long branch where most of the mining has been done. From the North Point eastward the conglomerate beneath the Kelly rises until it forms the surface of the broad arch that lies along the divide between Wisdom run and Trough creek in a territory where the plane of the Kelly coal rises above the surface. It is rare that one finds a point where both the pebbly phase of the Mahoning and the pebbly Butler are shown in the same hill side. This can be done, however, east of the road that leads from North Point to Dudley, about a mile northeast of North Point, at the mouth of a hollow that leads into the north branch of Six Mile run.

GENERAL SECTION ON SANDY RUN FROM THE POTTSVILLE TO THE McCUE BASIN COAL BED.

		Ft.	In.
22	Coal, McCue basin bed,	2	
21	Shale, sandy and shaly sandstone, greenish-gray,	160	
20	Sandstone, massive, brown, Upper Mahoning,	50	
19	Coal, Speer bed,	1	
18	Sandstone, grayish-brown, pebbly at base, Lower Mahoning,	52	
17	Sandstone, shaly,	5	
16	Coal, Kelly bed,	3	6
15	Shale, dark, clay,	4	
14	Sandstone, flaggy, brownish-gray,	12	
13	Sandstone, massive, local white pebbles,	50	
12	Coal, Twin bed,	1	6
11	Shale, dark, clay,	2	
10	Shale, sandy and thin sandstone,	20	
9	Coal, Barnett bed,	3	
8	Sandstone and shale,	10	
7	Sandstone, massive, gray; locally small, white, opaque pebbles,	20	

		Ft.	In.
6	Shale, sandy and shaly sandstone,	10	
5	Sandstone, massive, light-gray,	20	
4	Shale, sandy,	2	
3	Coal, Fulton bed,	3	6
2	Shale,	20	
1	Pottsville. In general section as measured near Hopewell. (See details of field).		

In the preceding section as given for Sandy run it must be remembered by the reader that the thickness and nature of the rocks are averaged as nearly as possible to apply to that general portion of the Broad-Top field. Greater detail naturally applies to the immediate vicinity of any one of the various mines. This section includes also in a general way, Long run and Kimber's run; but on these latter creeks exposures are to infrequent to enable the geologist to construct sections. On Kimber's Run, the coals have not been sufficiently opened below the Kelly bed to enable proper identification and measurements, for only massive ledges of sandstone outcrop in that rugged, timbered, region.

On lower Sandy run near the abandoned Zeth and Dodson mine (previously the Hopewell Coal and Iron Company) the detail of the stratigraphic succession is difficult to make out due to lack of sufficient exposures and the absence of diamond drilling. The supposed Kelly and Barnett beds have been opened there, but the steepness of the pitch and excessive mashing of the coal has made mining a difficult matter as will be discussed under the head of structure.

Just recently, what is apparently the Fulton bed has been opened by Mr. M. V. Zeth on the west side of the anticline that crosses Sandy run below the old workings. Between the point where the Fulton bed crosses the run and where the supposed Barnett bed was opened, there are signs of prospecting on what appears to be an intermediate bed, possibly at the same horizon as the bed above the Fulton in the old Scott shaft on Six Mile run. The nature of the folding, however, is so concealed that one can not be sure of the proper relationships. Within the mine there were numerous slips showing the results of intense pressure and along the run the rocks stand with dips of 30 degrees to vertical; the fact that the strike line changes its direction at two or three points nearby makes it practically impossible to ferret out the details of the section at that point along Sandy run.

Bed No. 7 of the Sandy run section, it will be observed contains at most exposures, small, white, opaque pebbles. Near the railroad cut below the mouth of Long run, bed No. 5 also contains similar pebbles. These pebbles are not larger than common peas and consist entirely of quartz.

The flaggy sandstone, bed No. 14, of the preceding section is rather persistent. In the neighborhood of the Cambria slope the next lowest

PLATE XIX.

View of Coaldale and the north slope of Six Mile Run from hillside above the Wigton Mine.

bed of the section, No. 13, is absent, but the flaggy, brown sandstone forms a bold exposure above the Barnett outcrop. This sandstone was seen at many places over the Broad-Top field and is common along the Trough Creek Valley side. The typical phases of weathered pieces are fairly good markers of this horizon. Certain layers are very fine-grained, hard, and high in their percentage of iron; they contain irregular patches of softer sand and clay with the greater dimensions along the bedding so that upon long exposures, hard, resistent pieces that lie about the surface contain, along their flat sides, numerous, small shallow, irregular cavities. Such pieces are often not over one inch thick and six inches broad and, picked up on the surface, are reddish gray in color.

The writer found, that in a study of the rocks of the whole field, these pieces of sandstone were characteristic of this horizon, but it is scarcely possible to describe them in sufficient detail that one, not familiar with them, might use them for purposes of correlation. When seen at many places, however, they come to be recognized. A careful study of the nature of the weathered exposure above the old Barnett prospect at the Cambria No. 2 slope on Sandy run will prove of value to any one wishing to become familiar with this rock. The interval from this bed, No. 14, to the Kelly is quite variable and at places contains greenish-gray, thin, sandstone and shale, as may be noted along the north side of Sandy run just above the Cambria slope, the thickness of this interval varies from a few feet to more than fifty feet.

The McCue basin coal bed, shown at the top of the Sandy Run section, is the bed that was formerly prospected in the McCue basin north of Stone Row and considered to be the Pittsburgh bed. It shows also by the roadside just above the top of the Langdondale shaft and again to the south of the road on the hillside at Stone Row. The fact that this bed has been confused with the Pittsburgh bed has given an exaggerated idea of the depth of the McCue basin, as will be discussed under the subject. "structure." Here the Kelly coal bed has been opened by a prospect; above the coal outcrop the surface contains pieces of the pebbly Mahoning and down along the creek below the coal, the Butler outcrops. Here the writer secured samples of the two conglomerates. Both contain small quartz pebbles and resemble each other in some respects, but the Mahoning sandstone invariably weathers brown, while the other sandstone inclines to be light-gray to nearly white. Pebbles in the Mahoning are not common while in the so-called Butler they are rarely absent, though frequently very small.

GENERAL SECTION IN EAST-BROAD TOP BASIN FROM THE POTTSVILLE TO THE BUTLER (?) SANDSTONE. RECORD OF WOODVALE SHAFT FURNISHED BY THE ROCKHILL IRON AND COAL COMPANY.

		Ft.	In.
24	Surface material,	6	10
23	Sandstone, (Butler) contains small, quartz pebbles,	16	5
22	Coal, Dudley (?) bed,	1	3
21	Under-clay,	4	3
20	Sandstone, fine-grained,	26	2
19	Shale, thin, hard, gray,	8	
18	Shale, sandy, light-gray,	4	
17	Shale, sandy, dark-gray,	38	
16	Coal, Twin bed,	2	6
15	Shale, dark-gray,	2	3
14	Shale, light-gray,	4	6
13	Coal, Barnett bed,	3	4
12	Shale, dark-gray,	0	5
11	Shale, light-gray,	9	8
10	Shale and thin sandstone,	24	0
9	Shale, soft, black,	4	4
8	Coal,	0	5
7	Shale,	3	11
6	Coal, Fulton bed,	2	9
5	Shale, dark, carbonaceous, Fulton bed,	1	0
4	Coal, Fulton bed,	1	4
3	Under clay,	3	(?)
2	Concealed, probably shale, about,	25	
1	Pottsville sandstone.		

In previous reports there has been considerable disagreement on the detail of the Robertsdale section, due to extreme paucity of exposures along Trough creek and the lack of reliability in diamond drilling with a three-quarter inch drill. The section as here given represents the detail of rocks penetrated in the Woodvale shaft as kept by the Rockhill Iron and Coal Company. This section represents the type of the strata along Trough creek reasonably well and in accuracy is within the limit of variation of the nature and thicknesses of the intervals.

At some points along Trough creek, as shown by recent drill holes by the Rockhill Iron and Coal Company, the interval between the Fulton and Barnett coal beds thickens to more than seventy-five feet and contains a local deposit of very hard, quartz conglomerate, the pebbles being not larger than peas; this latter bed gave great difficulty of penetration with the diamond drill.

The rock parting in the Fulton bed is variable in thickness and has been found at places to reach a prominence too great to permit of working the two benches of coal together by removing the parting; but this is an exceptional case with the bed. Likewise the interval from Barnett to the overlying Twin coal varies within considerable limits; it may be found at any distance above the Barnett from one foot to ten feet.

The thin bed of coal, No. 22, of the preceding section has heretofore been considered Kelly because of the fact that the pebbly sandstone above it, No. 23, has been correlated with the Mahoning that

PLATE XX.

Figure 1. Blocks of Butler Sandstone on hill above Shoups Run, near Dudley. Filled with small white pebbles, too small to show in picture.

PLATE XX.

Figure 2. Anticline between Melrose and Dudley, on Shoups Run, looking southeastward. Only one half of the fold is shown. The blocks show how rapidly the anticlines break down under the effects of weathering and erosion.

lies above the Kelly on the west side of the field; but it is the same member as the "top rock" about Broad-Top City that lies above the Barnett and just under the Kelly, and was once considered Mahoning because the Barnett bed there was once thought to be Kelly as discussed in previous paragraphs of this report. It is the writer's belief that the true, brown, Mahoning sandstone forms a bench on the hill just west of Woodvale and that the character of the Kelly coal bed from that point westward to the head of Six Mile run is yet to be proven by careful diamond drilling.

The following record of a diamond drill hole made southeast of Robertsdale in 1912 and submitted to the writer by the Rockhill Iron and Coal Company is as follows:—

RECORD OF DRILL-HOLE ON LANDS OF ROCKHILL IRON AND COAL COMPANY SOUTHEAST OF ROBERTSDALE.

	Ft.	In.
Surface,	15	
Shale, sandy,	12	
Shale, black,	0	8
Coal, Twin bed,	2	2
Shale and sandstone,	2	4
Coal, Barnett bed,	3	1
Shale, sandy,	27	9
Shale, black,	6	11
Coal,	0	6½
Fire clay,	1	0
Shale,	4	8½
Coal, Fulton bed	2	5
Binder, Fulton bed	0	8
Coal, Fulton bed	1	9
Underclay.		

LIST OF FOSSILS FROM BROAD-TOP COALFIELD.

Regarding the following list of fossil plants from the Broad-Top field, a word of explanation is necessary. Most of these collections were made in 1900 by Mr. David White of the U. S. Geological Survey, but no systematic or close study has ever been made of them. After small collections by the writer in 1912, a visit was made to Mr. White in Washington, D. C., and at that time all the slabs of shale containing the fossils were taken from their file cases in the National Museum and examined hastily by Mr. White; hence this preliminary list. The determinations were all made by sight without reference to any literature whatever. The list stands as a tribute to the remarkable familiarity that Mr. White has with the Coal Measures flora but he requests the statement made that these determinations are not to be taken as absolute. They are published for what they may be worth to those interested and if necessary the accessions may be inspected at the Museum. The one gastropod given at the end of the list is the only invertebrate found in the Coal Measures of the Broad-Top field.

Fossil plants collected in 1912 by James H. Gardner. Determinations by David White.

Fulton coal roof at Woodvale, in East Broad-Top.
Neuropteris Scheuchzeri.
Alethopteris Serlii.
Sigillaria sp.
Trigonocarpum cf. Noeggerathii.

Barnett coal roof at Alice No. 2. Kimbers Run.
Pecopteris hemitelioides.
Neuropteris Scheuchzeri.
Neuropteris Desorii (?).
Pecopteris cf. Miltoni.
Sphenophyllum sp.
Pecopteris cyathea (?).
Lepidophyllum cultriforme (?).

Barnett roof at Glendale Mine.
Neuropteris ovata.

Floor of coal bed at Delaware No. 3, Six Mile Run.
Abundance of Stigmaria roots.
Pecopteris pennaeformis (?).

Fossil plants collected in 1900 by David White. Determinations by David White.

No. 2440. Shoups Run. Gordon coal at New Hickas Mine. 20ft. below Fulton.
Sphenophyllum emarginatum.
Annularia stellata.
Alethopteris Serlii.
Lepidophyllum.
Neuropteris ovata.
Lepidostobus variabilis (?).
Lepidophloios sp. (?).
Lepidophyllum majus (?).

No. 2458. *Shoups Run. Fulton roof at Black's Mine.*
Lepidodendron dichotomum (?).
Neuropteris Scheuchzeri.
Alethopteris Serlii.
Sigillariostrobus (?).
Pecopteris.
Sphenophyllum emarginatum.
Lepidophyllum oblongifolium.
Annularia stellata.
Neuropteris ovata.
Sphenopteris sp.
Sigillaria sp. (Brardii group).
Pecopteris oreopteridia.
Pecopteris dentata.
Trigonocarpum Noeggerathii (?).
Insect wing. (Cockroach?).

No. 2441. *Shoups Run opposite side creek from depot. Fulton at Dudley.*
Alethopteris Serlii.
Sigillaria cf. tessellata.
Sigillaria cf. Brardii.
Neuropteris Scheuchzeri.

No. 2445. *Fulton at head of Shoups Run.*
Neuropteris Scheuchzeri.
Pecopteris?
Alethopteris Serlii.
Neuropteris sp.
Carpolithes ellipticus.
Cheilanthites sp.
Pecopteris cf. cyathea.
Lepidophyllum oblongifolium.
Sphenopteris sp.
Calamites Suckowii.

No. 2442. *Martins bank. Wray's Hill. Fulton coal.*
Neuropteris Scheuchzeri.
Sigillaria obvata.
Sphenophyllum emarginatum.
Sigillaria cf. tesselata.

No. 2443. *Sleemans bank. Rocky Ridge. Fulton.*
Lepidophloios sp.
Sphenopteris sp.
Lepidodendron oculatum.
Sigillaria.
Neuropteris Scheuchzeri.

No. 2461. *Eichelberger's Mine, Six Mile Run. Labeled Fulton but is probably Barnett.*
Callipteridium sp.
Annularia stellata.
Annularia sphenophylloides.
Pecopteris pennaeformis.
Neuropteris sp.
Sphenophyllum emarginatum.
Sphenopteris mixta.
Calamites Cistii.
Pecopteris Miltoni.

No. 2436. *Gates' Mine on Six Mile Run, Fulton.*
Pecopteris pennaeformis.
Neuropteris Scheuchzeri.
Sphenophyllum emarginatum.
Mariopteris cf. callosa.
Cheilanthites sp. cf. anceps.
Pecopteris pennaeformis.
Pecopteris dentata.
Calamites ramosus.

No. 2448. Shoups Run, Carbon Mines Barnett coal.
Cordaites sp.
Neuropteris Desorii.
Pecopteris Pennaeformis (?) (possibly villosa.)
Sphenophyllum emarginatum.
Neuropteris cf. Evenii.
Cardiocarpum sp.
Lepidodendron aculeatum.
Caulopteris.
Annularia stellata.
Lepidophloios sp.
Lepidocystis sp.
Pecopteris Miltoni.

No. 2446. Shoups Run, one mile west of Broad-Top City. Labeled Barnett but the age of the flora indicates a lower horizon. Oldest of the collection. Possibly from a prospect tunnel underground cut into lower rocks. (Pottsville?).
Lepidodendron cf. Wortheni.
Bothrodendron punctatum.
Annularia stellata.
Pecopteris sp.
Lepidophyllum (?) sp.
Alethopteris Serlii.
Sphenophyllum emarginatum.
Lepidophloios (?) sp.
Neuropteris cf. capitata.
Sphenopteris mixta.
Neuropteris sp.
Neuropteris vermicularis.
Neuropteris Scheuchzeri.
Neuropteris Clarksoni.
Sphenopteris sp.
Pecopteris unita.

No. ?. Sandy Run, Barnett coal, "A" coal above gap. Zeth and Dodson Mine.
Annularia ramosa.
Pecopteris sp.
Neuropteris ovata.
Neuropteris Scheuchzeri.

No. ? Barnett Coal at Powelton on Shoups Run.
Pecopteris like pennaeformis Lx.

No. 2460. Barnett coal at Robertsdale in East Broad Top.
Annularia stellata.
Neuropteris ovata.
Pecopteris cf. pennaeformis.
Pecopteris sp.
Calamites cf. Cistii.
Annularia Sphenophylloides.
Pecopteris dentata (?).
Neuropteris fimbriata.
Pecopteris cf. Miltoni.
Pecopteris cyathea.
Calamites sp.
Sphenophyllum emarginatum.

No. 2455. Kelly coal from Sandy Run.
Neuropteris? probably ovata.
Sigillaria Brardii.
Neuropteris Scheuchzeri. Very large form.
Pecopteris sp.
Sigillaria tessellata (?)
Neuropteris Desorii.
Pecopteris unita.
Stigmaria cf. minuta.

Pecopteris cf Pennaeformis.
Caulopteris.
Linopteris obliqua? More characteristic of Freeport coals than of the Kittanning group.
Scaly carapace of a *crustacean*.

Accession No. 54767, National Museum.
Cast of a stem of Calamites collected by Gardner from just over the top coaly streak in Pottsville 45 feet below the top in Hopewell Gap. The general aspect of the cast is that of Asterocalamites, a Mississippian genus. David White.

Gastropod from greenish shales at top of Mahoning sandstone, collected by Chester Langdon is determined doubtfully by George H. Girty. He says, "I suspect that it is *Trepospira sphaerulata*."

STRUCTURE AND TOPOGRAPHY.

Mention has been made of the fact that the Broad-Top field lies in a structural depression between the Tussey Mountain anticlinorium on the west and Jacks Mountain anticlinorium on the east side; more particularly the field is bounded on the west by Terrace Mountain and on the east by Sideling Hill, as shown in the sketch presented herewith, Plate XXI.

In the western portion of the United States such a topographic structure as the Broad-Top Mountain is termed a "mesa" being the Spanish word that signifies a table-land smaller than a "plateau" but larger than a "butte." Broad-Top Mountain is not flat on top such as are many of the western mesas, due to the fact that its measures are folded in such a manner as to produce uneven effects of erosion; but on all sides Broad-Top Mountain, or the Broad-Top Coalfield, drops away in the form of an escapement varying from 500 to more than 1000 feet in height. Reference to Plate XXII of this report will show the general aspect of the mountain; this cut is made from a photograph of a model of the mountain on the east side along Trough creek; it is remarkably true to nature.

Broad-Top Mountain is capped by hard rocks of the Coal Measures beneath which occurs the Mauch Chunk shale of a thousand feet or more in thickness. The shale of the Mauch Chunk, being softer than the rocks of the Coal Measures, has been more easily removed by erosion, thus lowering the country rapidly in the adjoining areas where the coal rocks have been removed; this leaves the coalfield much higher in elevation than the surrounding valleys in the Mauch Chunk.

The Pottsville rocks on the north side of the field form a high sloping rim around the strata that hold the workable coal beds along Miller's run and southward. At this point of the field the Pottsville has a considerable width and here it forms a high portion of Broad-Top Mountain from which the coal beds have been removed; this fact shows that the hard sandstones of the Pottsville are the controlling factors in the Broad-Top topography. On this edge of the field lies the topographic sheet known as the Huntingdon quadrangle, surveyed in co-operation by the State of Pennsylvania and the U. S. Government. It takes in a portion of the Pottsville escarpment. On the west side of the field, the Everett quadrangle barely takes in a portion of the Coal Measures from Riddlesburg south to Kimber's run.*

*These maps can be secured from the Director of the U. S. Geological Survey, Washington, D. C., at a cost of ten cents each; the bounding lines are parallels and meridians and the border lines touching the coalfield are labelel on the general map of the entire field presented with this report.

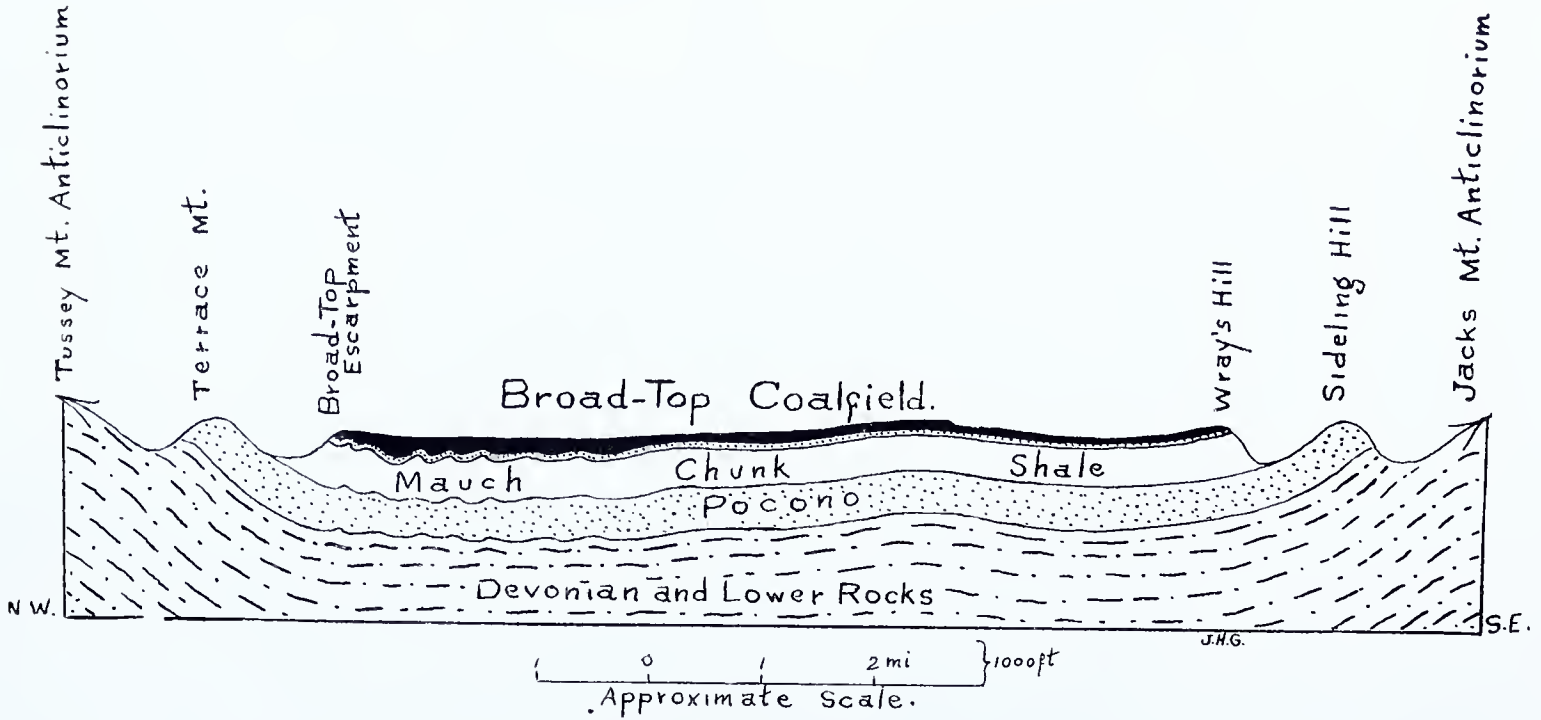


PLATE XXI.

Sketch from Northeast to Southeast across the Broad-Top field, showing its relation to structure and topography.

PLATE XXII.

East Broad Top Mountain as seen from the southeast.

Vertical Scale of Model 800; Horizontal Scale 1600 Feet to an Inch.

The following list of elevations above sea level are taken from various sources of instrumental surveys.

LIST OF ELEVATIONS OF SEVERAL POINTS IN AND BORDERING THE BROAD-TOP COALFIELD.

	Ft.	
Hopewell (U. S. B. M.)	901.82	
Riddlesburg (U. S. B. M.)	860.82	
Saxton (U. S. B. M.)	917.66	(Railroad 859.)
Newburg (U. S. B. M.)	1,169.	
Coalmont (railroad)	1,106.00	
Dudley Station (railroad)	1,414.3	
End of Shoups Run Branch of H. and B. T. M. R. R.	1.875.	
Defiance (railroad)	1,008.0	
Coaldale (railroad)	1,131.1	
Northpoint (railroad)	1,311.0	
Sandy Run Station; old Chevington Mine	1,297.5	
Everett (railroad)	1,118.7	
Robertsdale (railroad)	1,785.	
Cooks station (railroad)	1,541.	
Cole's station (railroad)	1,359.	
Sideling Hill Tunnel (railroad)	1,232.	
Broad-Top City (Pavement at Mountain House)	1,997.	
Round Knob (Barometic)	2,000.	
Old Cheney ore banks (barometic)	1,720.	
New Grenada	939.	
Wray's Hill above Sideling Hill Creek on Woodvale Road	2,150.	
Rockey Ridge over-looking Cooks	2,300.	
Head of Six Mile Run (barometic)	1,805.	
Rogers Knob north of Mt. Equity (barometic)	1,635.	
Fosters Mine	2,130.	
Kearney (Barnett Mine)	1,423.	
Kimbers Run, Alice No. 1 Mine	1,182.54	
Glendale, Cambria No. 2 about 145 feet above the Creek	1,555.	
Clippinger Mine	2,272.	
Woodvale (shaft)	1,861.	
Head of Trough Creek, about	1,950.	

Along the west side, except where cut through by streams, and on Wray's Hill on the east side, the top of the Pottsville lies at about 2150 feet.

The basin of East Broad-Top is shallow and broad being interrupted by small anticlines and synclines as shown in the workings of the Rockhill Iron and Coal Company at Woodvale and Robertsdale. Trough creek follows this basin until it leaves Broad-Top Mountain. The basin is a shallow syncline lying between the eastern escarpment and the Broad-Top arch; the latter is a broad, low, anticline, as shown on the cross sections, lying between the East Broad-Top basin and the group of synclines and anticlines that form the West Broad-Top basin. In the arched portion of the field there has been very little mining as yet. The workings on the Kelly coal bed at Finleyville are on the west flank of this fold and at the northern

extremnity it has been mined over by workings on the Fulton and Barnett beds at Broad-Top City.

The Westward extension of the workings at Robertsdale on the Fulton bed lie on the low dip of the east flank of the fold which corresponds to the west flank of the East Broad-Top, or Trough creek, syncline. The eastern boundary of the Kelly bed does not pass over the Broad-Top arch except between the head of Six Mile run and Woodvale; erosion of Trough creek and tributaries has removed it from the East Broad-Top basin, Wray's Hill, and Rocky Ridge. The long line of Rocky Ridge, with patches of the lower Coal Measures, lies in the northeastward extension of the East Broad-Top syncline. See Plate XXV, Fig. 1. The rise and fall of the basin along the strike has caused several patches of Coal Measnres to be left along the Wray's Hill and Rocky Ridge extension to the northeast. These are canoe-shaped areas remaining in the depressions of Pottsville rocks.

The Broad-Top Coalfield is divided into three distinct main divisions as regards the structure, in lines at right angles to the axes of folding. From the east rim of the field, known as Wray's Hill, westward to the Raystown Branch of the Juniata River, these divisions consist of (1) the East Broad-Top Basin, (2) the Broad-Top arch and (3) the crumpled measures of the West Broad-Top Basin. The reader is here referred to the cross-sections presented with this report showing this structure in natural proportions.

The longitudinal section across the field, parallel to the axes of the folds, clearly shows the manner in which the measures rise to the Pottsville rim. In all directions the rocks have a general rise to the Broad-Top escarpment; along Sandy run and Six Mile run the coal beds reach the lowest elevations in the field. On Lower Six Mile run, just below Defiance, a cross-roll carries the coals down to the lowest elevation in the entire field, the Fulton coal being depressed to an elevation of only 500 feet above sea-level.

It has been reported in the Broad-Top field that this is the lowest point that coal is found in Pennsylvania; but this is far from true. In the northern Anthracite field coals at the top of the Pottsville lie at a depth of 1500 feet below sea-level. In the bituminous field of Greene County, Pennsylvania, in the southwest corner of the State, some of the coals reach a depth of more than 500 feet below sea-level.

On the border of the Broad-Top field the top of the Pottsville, which is very close to the level of the Fulton coal, rises southward to an elevation of 1700 feet south of Kimber's run, and northward to 2300 feet over-looking lower Trough Creek Valley near Newburg.

In the West Broad-Top basin the most extreme cases of folding in the field are found. Here the greatest shortening of the measures took place as a result of horizontal pressure accompanying the general folding of rocks in the Appalachian Valley. The structure, how-

ever, is not nearly so abrupt as certain portions of the Anthracite field of Pennsylvania, where the folds are closed and in some cases over-turned.

As to why the folding was more intense on the west side than over the east half of the Broad-Top field, opens a general discussion of the mechanics of structure, involving various conclusions which, in this case, would be of a more or less theoretical nature. For some reason the horizontal pressure produced by the anticlinal folding on the two sides of the field, found its weakest zone between the Broad-Top arch and the first main anticline of the Tussey Mountain uplift. This zone is of the type that Willis[c] calls "incompetent structure," meaning that the rocks were not sufficiently strong to resist the necessary horizontal pressure to raise the adjoining anticlines.

The lithologic variation of the rocks composing the section of the coal measures in Broad-Top seems to bear out the idea that the rocks of the Broad-Top arch and the East Broad-Top basin were naturally stronger and not so easily folded as the rocks of the west Broad-Top basin. In this connection it should be noted that horizontal pressure against a section of rocks of varying strength, as taken across the measures vertically, will find its weakest zone where the total strength of the strata is least. This strength depends on the original source and deposition of sediment and involves physiographic conditions at the time the rocks were formed. In one locality a formation may be largely shale and at another point chiefly sandstone, as is true of the rocks in the interval between the Fulton and Barnett coal beds in the Broad-Top field. Such a formation would resist horizontal pressure irregularly; the shale would be less competent than the sandstone, being more easily compressed and having a tendency to slip along the bedding or lines of contact. Just so, the total strength of a very great section of rocks at any one point depends upon the character of the materials as determined in original deposition.

So far as can be determined, the total strength of the Coal Measures section was probably stronger on the east side of the Broad-Top field than on the west side. On the east side a very hard conglomerate and much sandstone is found between the Fulton and Barnett beds; the interval between the Barnett and Kelly is thickened, with the development in this interval of a massive conglomeratic sandstone at the horizon of the Butler sandstone; possibly there were additional corresponding terranes of stronger rocks in the eastern portion that caused the resistance that raised the Broad-Top arch and did not permit the crumpling of the strata there.

The subordinate synclines of the West Broad-Top basin are long, narrow and relatively deep; the intervening anticlines are very narrow and closely folded at the crests. The miners and operators of

(c) Willis, Baily. "The Mechanics of Appalachian Structure." U. S. Geological Survey, 13th Annual Report, Pt. 2.

the field naturally think of the synclines, or "basins," as the principal structures; the mines are laid out lengthwise along the basins with headings running back to the steep crests of anticlines on either side, and for this reason the anticlines are considered as the limiting factors in taking coal from the basins. Consequently those interested in mining coal from such a region have their attention attracted to the continuations of the basins as the essential structures, though the anticlines are, of course, parts of such folds, but the miners give names to the *basins* rather than to the *anticlines* as will be seen by reference to the cross-sections. Plate XXIII.

Across the west side of the Broad-Top field the basins are remarkably persistent, some of them running the entire length of Broad-Top Mountain, with astonishing regularity of width and direction. In the report on Bedford County in 1882, Prof. J. J. Stevenson correlates certain folds of Broad-Top Mountain with those running southward across the county. From west to east in the coalfield his identifications were as follows:—(1) The western division of the Clearfield synclinal; (2) the Grey's Run anticlinal; (3) the eastern division of the Clearfield synclinal; (4) the Sheaver's Creek anticlinal; (5) A series of folds; (6) the Broad-Top anticlinal; (7) the East Broad-Top basin.

Regarding the classification of the series of folds, No. 5 in the preceding list, Prof. Stevenson states (Volume T 2 p. 43); "The folds between the Sheaver's Creek anticlinal and the Broad-Top anticlinal cannot be identified with those occurring farther south. Clearly some new folds have come in by bifurcation so that the synclinal and complex anticlinal of Snyder's ridge cannot be recognized in detail, and local names must be applied to the folds occurring in this interval." He then gives a list of names for the local anticlines and synclines of that interval. The writer thinks best to omit this latter list on account of the confusion it might bring with names that have come into common use as mining has progressed in the coalfield. The names of the basins are given on the cross-sections accompanying this report. The anticlines are not named by the operators in the field for the same reason that it brings confusion to a discussion of the structure. Any anticline is designated by its relation to the synclines as, for instance, "the anticline between the McCue basin and the Duval basin;" or "the anticline between the Langdondale basin and the Cambria basin," etc.

For the purpose of correlation with the names as used on the cross-sections, the writer wishes to state that the "Grey's Run anticlinal is identified on Sandy run by Prof. Stevenson at the first railroad cut above Hopewell. (See Plate 24, Figure 2, of this report). This is the anticline between Judith basin No. 1 and Judith basin No. 2. The eastern division of the "Clearfield synclinal" is the McCue basin, while the "Sheaver's Creek anticlinal" is the

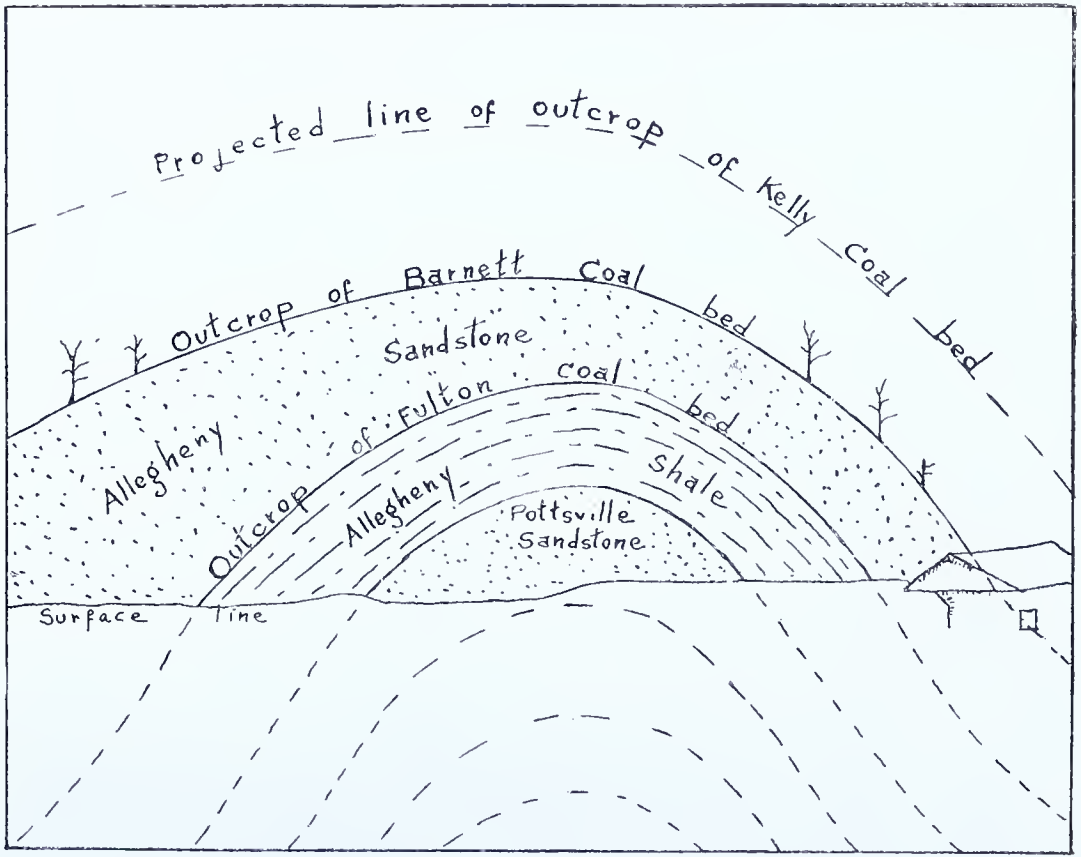


PLATE XXIII.

Figrue 1. Sketch of anticline just east of Cambria No. 2 slope on Sandy Run. See photograph, Figure 2.

PLATE XXIII.

Figure 2. Photograph of Anticline just east of Cambria No. 2 slope on Sandy Run. See Figure 1.

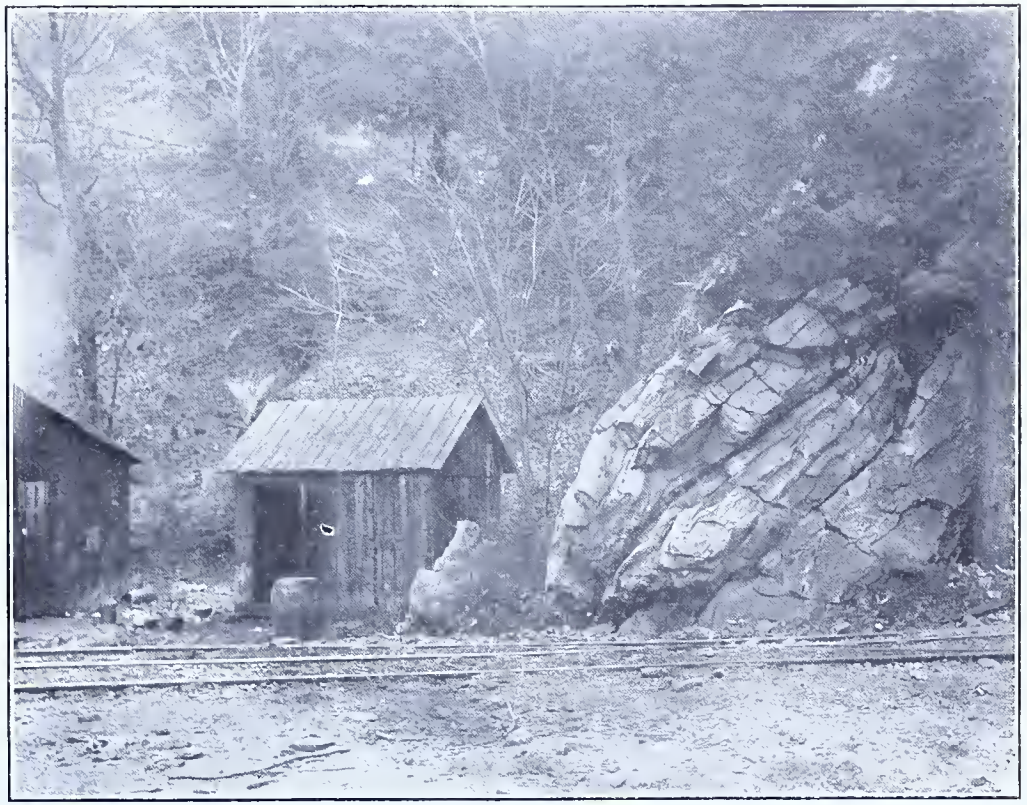


PLATE XXIV.

Figure 1. Outcrop of Homewood Sandstone, dipping steeply eastward, at Gordon Mine, on Shoups Run.

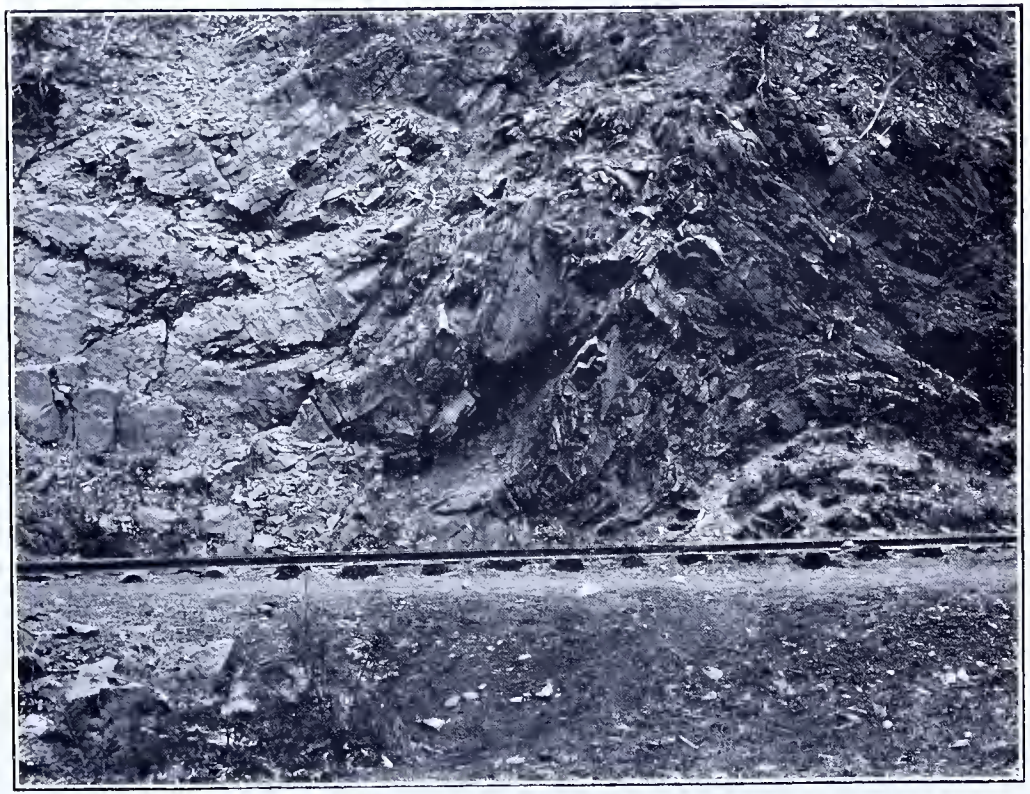


PLATE XXIV.

Figure 2. Anticline on Sandy Run, at first railroad cut above Hopewell.

anticline between the McCue basin and the Langdondale basin. These two latter structures pass entirely across Bedford County, through and beyond the Broad-Top field into Huntingdon County. Prof. Stevenson speaks of the eastern division of the Clearfield synclinal (McCue basin) (Vol. T 2, p. 41) as being much the deepest basin in the field which is quite true; the depth refers, however, to the elevations of the coal beds with respect to sea-level and not to the depth of the basin as compared with the crests of the anticlines on either side.

The basins of the West Broad-Top field vary in width from 100 to 3000 feet, and will average about 1500 feet over a considerable portion. Their depths as compared to the heights of neighboring anticlines vary from zero to about 200 feet as may be seen by reference to the cross-section.

Not all the folds are continuous across the entire coalfield, as may be seen from the lines of anticlines drawn on the map. On the sheet showing structural contours on the Kelly coal bed note, for instance, how the southward extension of the Wilson basin canoes out against the Langdondale basin. Towards Shoup's run the folding is less intense, as a general proposition, than farther south. Along the lower portion of Kimber's run, at the southwest extremity of the field, the folds are very narrow and exceptionally steep. At the present writing the Kimber's run territory is not sufficiently developed to enable the writer to present an accurate cross-section of the measures there nor to properly discuss the possibilities of that section for mining coal. Exposures are few and very unsatisfactory for the purpose of determining all the structural features from a study of the surface. Diamond drilling should be done over this district in advance of any attempt to extract the coal on a large scale.

A glance at the map of the Broad-Top field will show how the structure has influenced erosion and determined the shape of the field. The close crumpling of the rocks on the West Broad-Top side has caused them to resist the effects of erosion, thus producing two long ends, one southwestward to the north side of Sherman's run, the other northeastward beyond Miller's run toward Newburg. Close folding of rocks, under such conditions as are found here, protects them from the effects of degredation; débris resulting from surface weathering is caught and held in the steep synclines while the corresponding anticlines are truncated only to a common level; besides the whole zone of folding is subordinate to one large syncline known as the West Broad-Top basin.

In a similar manner two ends of the field are produced on the East Broad-Top side by the Trough Creek syncline, known as the East Broad-Top basin. To the southwestward it produces the point near Well's Tannery while northeastward it forms the long, narrow extension of Wray's Hill known as Rocky Ridge. (Plate XXV, Fig. 1).

The fact that the three workable coal beds of the Broad-Top field lie low in the geologic section has been a very important factor in their protection from erosion. The three beds are usually found within the first 150 feet above the top of the Pottsville sandstone; for this reason the rise of the coal beds at points along the strike of the anticlines is not sufficient to bring them out to the surface; an exception to this statement is noted along Wray's Hill and Rocky Ridge where erosion has removed the larger portion of coal rocks above the Pottsville, leaving patches here and there of the lowest coal.

Not infrequently in the underground workings on the coal beds, structures known as "rolls" are encountered. These are sudden folds in the measures running diagonally across the basins. They have resulted from the effects of longitidinal pressure. Some of them are not deep seated, being confined to the rocks above a certain level, or to the measures immediately inclosing a coal bed. There has no doubt been a slipping of a certain portion of the strata over another portion in the case of most rolls. (See Plate XXV, Fig. 2). The thickness of the measures involved depends on the magnitude of the roll.

Along Six Mile run, in the vicinity of Defiance, a roll suddenly carries the coal beds down to a depth of 350 feet lower than the level of the disturbance at this point. This roll was encountered at the south side of the workings in the Durham Colliery, as is shown by the structure contours on the Kelly coal. The roll encountered in the workings of the Huntingdon Coal Company north of North Point is a recurrence in line with this same disturbance. At that point it influences the crop-line of the Kelly coal bed in a very peculiar way, apparently carrying it through between two branches of Six Mile run in the form of a V-shaped wedge, making a narrow band as shown on the map. The roll shows plainly on the two hill sides that rise from these two branches of Six Mile run, but the intervening territory is a woodland with no exposures.

The Kelly coal bed has been prospected at both ends of the roll but the work promptly abandoned for obvious reasons. On the main branch of Sandy run, about one mile above North Point, an opening was made in a coal bed above the Barnett, at Delaware Mine No. 3. This working was soon abandoned on account of the condition of the coal, it being mixed with bone, shale, etc. It is quite possible that this is the Dudley bed, though it was then thought to be at the horizon of the Kelly bed. Further up the creek the undoubted Kelly bed was prospected in a shaft at the roll. The coal opened at Delaware No. 3 is apparently carried below this horizon by the downward deflection of the roll.

Faults are the exception rather than the rule in the coal rocks of the Broad-Top field. Now and then the term is misapplied to what

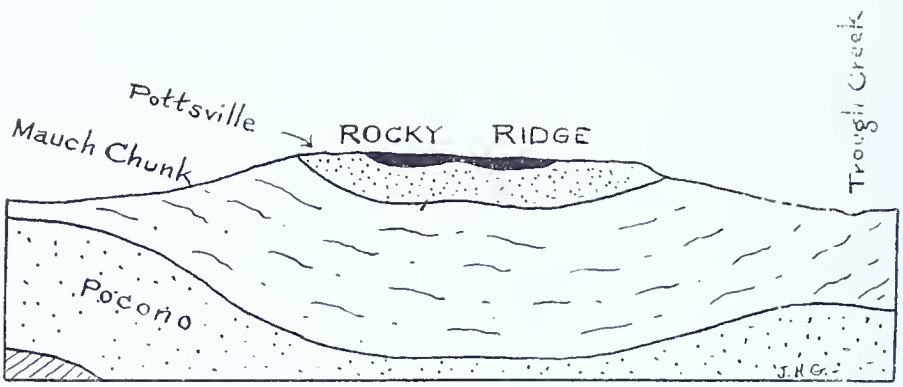


PLATE XXV.

Figure 1.—Cross section of Rocky Ridge, north of East Broad-Top Railroad, showing synclinal nature of the ridge and position of the small area of coal measures remaining.

PLATE XXV.

Figure 2.—Sketch, showing manner in which a "split" is produced by an over thrust roll. Illustrated by local conditions in Jrdith and Rock-bar Mines.

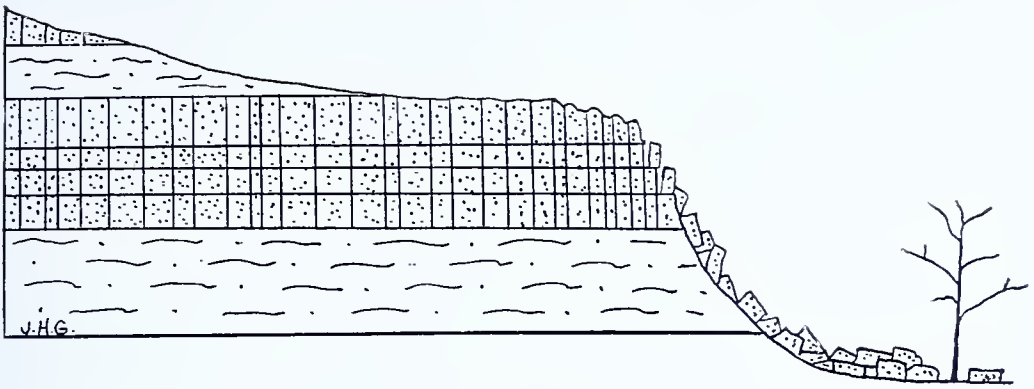


PLATE XXVI.

Sketch, showing manner in which vertical jointing in sandstone produces oblong prismatic bowlders along the outcrops.

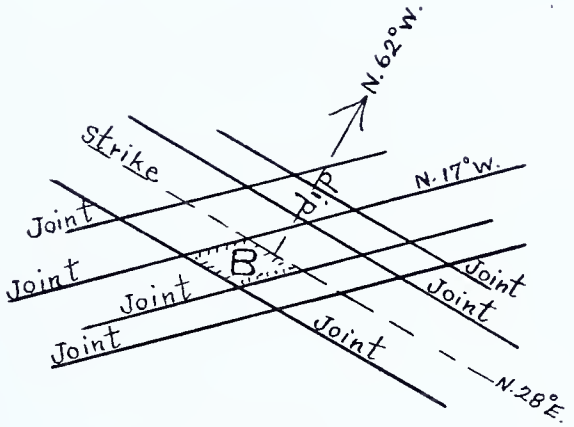


PLATE XXVI.

Figure 2. Sketch, showing relation of joints to dip and strike lines in Mahoning sandstone on north side of Bunker Hill, at head of Long Run

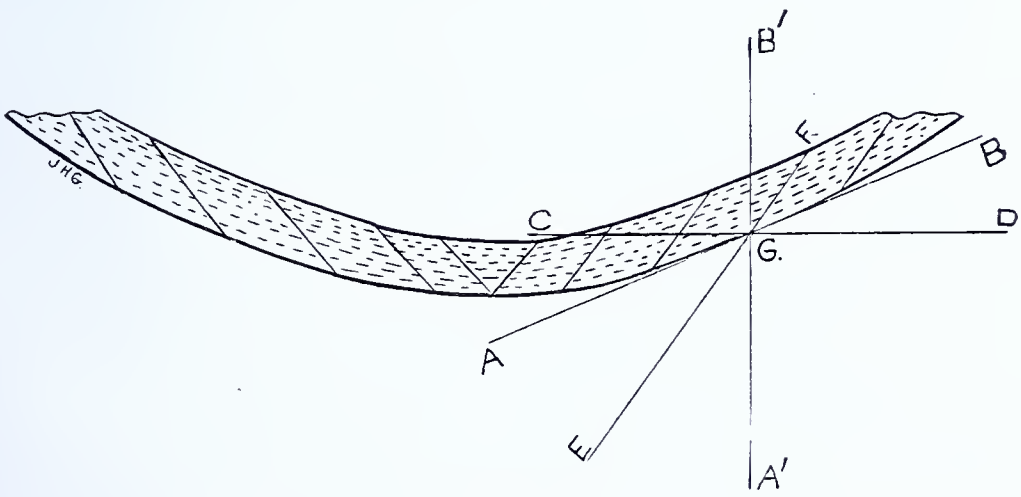


PLATE XXVI.

Figure 3. Sketch, showing relation of the jointing in a coal bed to the vertical and tangential components of folding. The joints tend to bisect the angle between the tangent and the perpendicular.

is more commonly called a "squeeze" meaning a point where the coal bed is entirely mashed out by extreme pressure and slipping between the roof and floor of the bed. When faults do occur they are usually confined to the immediate rocks inclosing the coal bed and do not necessarily affect the strata at the surface: they are of the pattern that would be produced in such a structure as illustrated in Plate XXV, Fig. 2, of this report, in a case where the rocks were broken at the fold. Such a condition is reported at one point in the workings at Robertsdale, and in the early workings at the Mt. Equity mine. Again the term fault is applied to a steep "roll" that suddenly carries the coal up or down from the level of a working face in a mine; such a roll is in practically every case accompanied by a "squeeze" or a "split" as shown at point C in Plate XXV, Fig. 2. This is the character of the structure illustrated in workings at the Judith and Rock-bar mines.

In the case of a simple "squeeze" in which the coal is mashed out between the roof and floor there is always a corresponding thickening of the bed at a point adjacent to the squeeze, where the coal has accumulated. This condition was well shown in workings of the old Powelton, or Melrose mine on Shoup's run and described as follows by I. C. White in Volume T 3 p. 307,—"The west dip of the eastern anticlinal is rapid, and a "rock fault" runs along its crest for 1600 feet. This "rock fault" is a narrow area on the crest of the anticlinal where the coal has been squeezed off from the crown of the arch almost entirely, and piled up in the syncline west from it, where Mr. McCue reports that the coal was in some places 20 to 30 feet thick."

Jointing is found in the whole stratigraphic section in all parts of the Broad-Top field; by jointing is meant the small breaks across the bedding of strata that have resulted, in the present case, from the pressure of uplift and folding. Every outcrop of sandstone in the field shows jointed structure, and for this reason they weather down in prismatic bowlders as illustrated in Plate XXVI, Fig. 1, of this report. These joints bear a definite relationship in direction to the lines of folding; they have a tendency to develop first of all in a direction parallel to the strike, as breaks take place in folding a piece of card-board. In the bending, or folding, of any material a greater tension is naturally set up on the outer than on the inner surface of the curve and lines of fracture are apt to result if the substance be of a brittle nature. Plate XXVI, Fig. 1.

The deeper rocks lie beneath the surface at the time of folding the less liable they are to show jointed structure. Besides the joints that run parallel to the strike, another set of joints tend to develop at some angle between the line of strike and the direction of the dip. These joints probably develop from the "canoeing" effect in folding or as a

result of stresses set up due to changes in the direction of the strike. Near the top of Bunker Hill, toward the head of Long run, the writer found a smooth surface of Mahoning sandstone that shows two sets of joints so definitely developed that measurements could be made on their directions very accurately; the sketch of Plate XXVI, Fig. 2, is based on this observation. The reader will note in this instance that the joints diagonal to the strike line make angles and complements of exactly forty-five degrees with the joints that parallel the strike. This is coincidental, however, since this angle depends on forces that are not constant except for local areas. Similar sets of joints as described are common to the Broad-Top field and many bowlders are seen that show a cross-section similar to that shown at B in Fig. 2, Plate XXVI.

As regards jointing in coal, conditions are identical and the results concordant with the descriptions as applied to sandstone, and common also to the shale beds. Plate XXVI, Fig. 2. In Plate XXVI, Fig. 3, the writer has made a sketch of the jointing as found at Robertsdale and Woodvale on Trough creek, and well shown in the Fulton coal at the Alloway mine. In this case the reader will note that a cross-section is shown of a small basin in which prominent joints run parallel with the strike and dip toward the center at an angle greater than the dip of the coal bed. They dip to the center from either side, forming a V-shaped block in the bottom of the syncline.

In mining coal at the face of a "dip-heading" in the mines of the Trough Creek district the miners must exercise care, at places, lest these large blocks that slope from roof to floor in the direction of the heading, suddenly fall upon them. The line E——F in Fig. 3, Plate XXVI, is the continuation of a joint plane dipping at right angles to the strike of the coal rocks. The line A——B is drawn tangent to the curve of the basin at the point where the joint intersects it at point G. A'——B' is the line of the perpendicular at right angles to the horizontal line C——D. Observations on these joints show that they are related to the components of folding so that they tend to bisect the angle between the tangent and the perpendicular, the line E——F equally dividing the angle, A G A'.

The fact that joints permeate the rocks so extensively in Broad-Top field causes coal under slight cover to readily deteriorate. When a bed lies within less than 50 feet of the surface and is covered by a thoroughly jointed sandstone, such as the Mahoning that overlies the Kelly bed, the conditions of the coal are apt to be such that it is not profitable to mine it. Not only do weathering agencies affect the coal but the unequal settling of the heavy, detached, masses of sandstone mash the bed out of proportions. Such cases are not extensive in the field, however, and over the territory at present mined no great difficulty has been encountered from this source.

ECONOMIC RESOURCES OF THE FIELD.

It is needless to say that coal is the leading natural resource of Broad-Top Mountain. In fact there is little of importance at the present time in the field outside of coal and the industries that are dependent on it or coke. Building stone, flag-stone, fire-clay, brick-clay, sand, timber and a little limonite iron ore furnish some possibilities for the future, but they are of no great importance, unless it be timber through reforestation.

At one period during the operation of the old iron furnace at Hopewell a considerable amount of iron ore is said to have been mined at the old Cheney ore banks shown on the map between Sandy run and Kimber's run in Bedford County. At the time of the writer's visit the old pits had fallen so that the deposit is no longer visible; but pieces of the ore lie strewn about the surface.

Mining was carried on here in 1846. The ore is limonite and reported to run between 33 and 40 per cent. metallic iron; this statement was made by Mr. M. B. Zeth of Hopewell who is familiar with the ore as used at the furnace. This bed lies above the Pittsburgh coal at a horizon found in Broad-Top at very few of the high points, as shown by the spots colored purple on the geological map. The bed was noted by loose pieces of ore near the top of Roger's Knob and Round Knob but no idea could be gotten as to thickness. Above the bed is found a thin limestone as shown in the columnar section. This limestone is too siliceous to make suitable agricultural lime and is too hard to be economically ground for lime carbonate, besides being too thin to be profitably mined. It is probably not over 4 feet thick at any point and runs through the steep knobs under heavy cover. No other limestone beds of the field are thick enough to be of any economic interest.

In the upper shale bed of the Pottsville, just under the Homewood sandstone, a bed of iron carbonate, or siderite, is usually found consisting of kidney-shaped or disc-shaped concretions; these are scattered through eight or ten feet of carbonaceous shale but are of no commercial importance. Upon weathering gray iron carbonate produces brown limonite, a fact that should be remembered by prospectors for iron ore at this horizon.

A number of the sandstones of the Coal Measures could be used for building purposes. They are thoroughly metamorphosed and as a rule exceedingly hard. Either the Pottsville or Mahoning sandstones should make excellent grades of durable stone; in fact most any of the beds of the series are hard and strong. Many old chimneys can be seen still standing in good condition that have withstood the effects of time for scores of years. Local sandstone was used for the old charcoal furnace at Hopewell constructed in 1802,

yet it stands in good preservation after more than a century of exposure to all sorts of weather. (See Fig. 1, Plate XIV.) Jointing in the sandstone causes them to break down in large blocks, a fact that facilitates quarrying for stone of limited dimensions. At the Raven Rocks, on a branch of Shoup's run, east of Coalmont and south of the Gordon mines, thin bedded sandstone in the Pottsville was once quarried for flagstone.

At the top of Shirley Knob near Jacobs' mines, at the north end of Rocky Ridge, a bed of hard fire-clay has been prospected to some extent. This bed lies near the base of the Allegheny Series and has been considered the same as the under-clay of the Fulton coal bed, the latter and all higher coals having been removed by erosion from that point. The clay is gray in color and of the hard, flinty or semi-plastic type that breaks in the form of sharp-angled pieces. In a drill-hole near Jacobs' the clay beneath the Fulton bed shows a thickness of six feet, which is probably a fair average for the bed in this territory.

The flint type of fire-clay is common beneath the Fulton and Barnett coal beds on the East Broad-Top side of the field, but usually contains a high percentage of iron content that lowers its refractory nature; it is exceedingly heavy and not of a uniform composition. It may be that this variety of clay can be successfully used for refactory products at certain places in the Broad-Top field but thorough tests, both as to uniformity of occurrence and quality, should be made in advance of any plans for mining it. It is reported that a movement is on foot to utilize the clay at Shirley Knob. Some years ago tests were made of a clay-shale above the Barnett bed at Robertsdale with the hope of finding it suitable for brick; but the results were unsatisfactory for some reason not reported to the writer.

Along the wagon road leading from Woodvale toward the Alloway mine, a heavy iron-bearing, flint-clay outcrops beneath "smut" of the Barnett coal crop. The bed is ten feet or more in thickness here. It was penetrated in drill holes southeast of Robertsdale where it is nine feet thick and described as shale of light-gray color. This clay may be found to have a less percentage of iron, or fluxing material, when gotten in a fresh condition at the point mentioned near Woodvale and it seems that a practical test of a large sample from this locality would be justified.

Pieces of flint fire-clay were observed on the surface at several points between the Barnett and Kelly coal beds, in each case probably at the horizon of the Dudley coal bed, but in no instance could a suitable exposure be found for measuring the deposit. Toward the head of Long run, on Kimber's run and near the head of Six Mile run such pieces were seen at this position.

The Fulton, Barnett and Kelly beds have either plastic or sandy under-clays at most places; the deposits vary from two to four feet in thickness. These clays may possibly be used in the manufacture of a fair grade of brick.

At one time Broad-Top mountain was covered with good timber but the ravages of the lumbering industry have removed the original forests. Second growth chestnut and the different species of oaks are reaching good dimensions, however, in certain sections. In other regions the third growth has even developed to fair sized trees. Sixty years ago the timber supply was heavily drawn on for the burning of charcoal and following that came a growing demand for lumber, posts, mine-props, etc. In recent years the last virgin timber was removed from Kimber's Run. Along Trough Creek Valley considerable second growth pine has reached milling size but this is being rapidly consumed. With proper care and supervision, some of the companies owning large properties could well afford to reforest the land or at least clear away the brush and trim the young trees, giving them the best natural opportunities for growth.

NATURE AND OCCURRENCE OF THE COAL BEDS.

The three commercially important beds of the Broad-Top field are in ascending order, the Fulton, Barnett and Kelly. All are in the Allegheny Series and in all probability are the same as the Clarion, the Lower Kittanning and Upper Freeport coal beds of the bituminous field west of the Allegheny Front. Over five hundred feet above the Kelly a bed of workable thickness is found, corresponding probably to the Pittsburgh bed; but its area is limited to five small patches in the tops of knobs. The Twin bed just above the Barnett is worked locally in conjunction with the Barnett, but is not thick enough to be mined separately at the present price of coal. At local points the Speer bed, in the Mahoning sandstone, above the Kelly, and the Phipps bed in the Conemaugh, are thick enough to attract some interest but are not mined. The beds will be taken up under separate heading.

COAL IN THE POCONO FORMATION.

From time to time interest and more or less excitement has been aroused by what is purported to be a discovery of some extension of the Broad-Top field into new territory adjacent to Broad-Top mountain. Such "discoveries" usually are based on out-croppings of coaly shale or seams of coal of one to six inches in thickness that occur in the gray sandstones of the Pocono formation, over 1000 feet, geologically, below the Coal Measures of Broad-Top. This formation rises to the surface on all sides of Broad-Top Mountain and these coal streaks are to be expected at any point around the field. They occur west of the Raystown Branch of the Juniata near Hopewell, in Terrace Mountain, in the "Barrens" of Lower Trough creek, in Sideling Hill, and the high hills south of Sherman's run or Ground-Hog Valley. The sandstone beds of the Pocono can scarcely be distinguished from those of the Coal Measures in appearance and it is but natural that this mistake should be made. Often considerable time and money is needlessly expended in prospecting these beds. There are a dozen or more of these thin streaks in the Pocono, but not one of them contains coal of any importance whatever.

It is the writer's opinion that there are no hopes of discovering any extension of the Broad-Top field from what is shown on the geological map presented with this report. The general conditions of structure and topography indicate that the Coal Measures are confined to Broad-Top Mountain and of such Broad-Top Mountain is made.

COAL IN THE POTTSVILLE GROUP.

No workable coal is known in the Pottsville of the Broad-Top field. There are two horizons at which coal streaks are found in bituminous shale; one below what corresponds to the Conoquenessing sandstone, and is likely the Sharon coal horizon: the other lies just below the Homewood sandstone and probably corresponds to the Mt. Savage or Mercer horizon. These two coal streaks are shown as measured near Hopewell in the columnar section, Plate No. III. On the east side of Frough creek, just below Robertsdale, the bed at the Mercer horizon, just below the top of the Pottsville, is said to consist of about two feet of coal separated by layers of shale and bone. This is the nearest approach to workable coal that the writer could learn of in the entire field.

THE GORDON COAL BED.

The Gordon coal is named by the writer from an exposure of the bed at the Gordon mine on Shoup's run. At that point it shows a thickness of one foot of clean coal, twenty feet below the Fulton. It is the lowest of the Allegheny coals and probably correlates with the Brookville bed of Western Pennsylvania. The bed is not persistent but is found at a number of places and rarely exceeds one foot in thickness. In a columnar section by John Fulton in 1883, he shows the bed two feet thick in the East Broad-Top basin; but this is a local thickening of the bed that is uncommon. It is found as a thin seam in the section just above Riddlesburg on Six Mile run and is known locally on Sandy run.

THE FULTON COAL BED.

The Fulton coal bed was named for John Fulton, Mining Engineer, who was at one time associated with Cambria Iron Company, and who did a great deal in the early developments of Broad-Top coal mining. The same bed had previously been called the Cook Coal bed for Jesse Cook, who operated the old Cook mine at Broad-Top City. The name Fulton had been applied at Dudley to what was supposed to be a bed far below the Cook coal; but when the mining industry developed sufficiently along Shoup's run, it was proven that the Cook and Fulton was identical.*

But although the name Cook was first applied to this bed the name Fulton was adopted throughout the Broad-Top field, and is now used almost exclusively.

The Fulton coal bed varies from three to five feet in thickness, and usually contains at least one parting of bituminous sandy shale, referred to as a "rock parting" by the Broad-Top miners. For details of sections in the various portions of the field see the accompanying sheet which shows them drawn in columnar form.

*For details of this discovery read pages 30, 31 of this report, under Stratigraphy.

The Fulton bed has been extensively mined on Shoup's run and in the East Broad-Top basin; to some extent also on Six Mile run. On the south side of the field it is yet to be developed.

The Fulton bed, like the Barnett and Kelly, is so far as known persistent within its entire outcrop. But the fact that the Fulton bed contains an admixture of shale in the form of partings will make the mining of this bed a difficult matter on the lower portion of Six Mile run, Sandy run and on Kimber's run, where the folding has been so excessive that the shale is mashed into the coal; it is probable that local conditions will be found to correspond with those of the anthracite field, where it is necessary to separate the rock from the coal after it is mined. But over the Broad-Top anticline and in the Trough Creek or East Broad-Top basin it will likely prove to be a valuable bed such as it is known to be in the districts where it has been mined. For a discussion of the comparative value of the bed see heading "Character and Quality of the Commercial Coal Beds."

THE BARNETT COAL BED.

The Barnett coal bed gets its name from Philip Barnett who opened the old Barnett mine at Dudley on Shoup's run. It lies at an average of about fifty feet above the Fulton bed and its average variation in thickness is from three to four feet. It is usually free from large partings and is a persistent bed, being found throughout the entire field except where it has been removed by erosion. It usually carries four to six inches of bone coal at the top and frequently is divided into different benches by thin bone or shale partings.

The Barnett bed, like the Fulton, has been mined more extensively on Shoup's run and in the East Broad-Top basin than elsewhere. To some extent, however, it is mined on Six Mile run, Long run and Sandy run. It is mined at Jacobs' mines on Rocky Ridge in a small basin where the Fulton coal is also mined.

Over a large undeveloped territory in the Broad-Top field the Barnett bed will undoubtedly be found workable. From the accompaning sheet showing various measurements in columnar form the reader can readily get a knowledge of the nature of its occurrence in various sections of the field.

At the A. J. Wishart country mine in Fulton county the Barnett bed shows a thickness of four feet of coal with only two thin bony streaks, thus indicating that the bed will hold up to its reputation over a large undeveloped territory at the head of Trough creek and over the Broad-Top arch to the west Broad-Top side. The Barnett and Fulton beds keep close together around the outcrop, due to the small interval between the two and, lying as they do near the top of the Pottsville, they outcrop close to the outer edge of the field ex-

cept to the long northeast rise where all rocks have been removed down to the hard, resistant sandstone of the Pottsville.

The Barnett bed will, in all probability, supply the largest amount of recoverable coal in the future mining in the Broad-Top field. The Twin coal bed that lies above it is found locally close enough to the Barnett to permit of the two being mined together. For a discussion of comparative values see heading "Character and Quality of the Commercial Coal Beds."

THE TWIN COAL BED.

In the columnar sections showing the thickness of the Barnett bed it will be observed that in one vicinity on Shoup's run, and in the East Broad-Top basin, a bed is shown above the Barnett in the mine sections and labeled the Twin coal bed. It gets its name from the fact that it occurs locally as a Twin bed within a few feet of the Barnett, so that the two beds can be mined together. It is a separate bed, however, over most of the field. Its height above the Barnett is exceedingly variable but it is rather peristent and is always expected within twenty-five feet above the Barnett. It is usually a solid, clean bench of coal rarely as thick as two feet.

The interval between the Barnett and Twin beds is usually sandy shale, though at the Wigton or Cunard shaft on Six Mile run the interval consists of considerable sandstone, while toward the mouth of Six Mile run and on Sandy run the entire space is taken up by massive sandstone, even to the complete exclusion of the Twin bed.

THE BARNETTSTOWN COAL HORIZON.

In the vicinity of Barnettstown and Dudley on Shoup's run two thin beds of coal are exposed at a horizon forty feet above the Twin bed. Nine feet of shale separates them, the lower bed being eight inches and the upper sixteen inches thick. It seems likely that the two beds may represent the horizon of the Upper Kittanning coal. Coal at this position in the measures is of a very local occurrence and was not seen in any locality except on Shoup's run. The beds may be seen on the steep hillside in the center of the Dudley basin on the north side of Shoup's run, near the Dudley depot.

THE DUDLEY COAL BED.

On the branch of Shoup's run that heads southward from Dudley and just south of the town, a coal bed of no commercial value, but of considerable geologic interest, has been opened.

This horizon has been considered by some as the Kelly bed. The same bed was once exposed 100 feet above the Barnett at the old Ocean mine. At a point 125 feet higher a four-foot bed is found in

the hills toward Six Mile run that is the true Kelly bed, overlain by massive, brown, Mahoning sandstone that can be traced around the outcrop westward to the property of the Mt. Equity Coal Company and thence to Six Mile run. But the bed exposed lower down at Dudley is 125 feet lower in the series and is designated the Dudley bed, corresponding in all likelihood to the Lower Freeport coal. A massive sandstone below the bed lies in the position of the Freeport sandstone; some distance above the bed. a massive sandstone carries quartz pebbles and falls in the position of the Butler; this conglomerate has been confused with the Mahoning. It is the so-called "top rock" at Broad-Top City, and in the Trough Creek Valley. At one time it was confused with the Pottsville, and on this interpretation the Pottsville was shown at the surface along the Broad-Top anticline in the geologic map of Fulton County published in 1882.

In the report on Huntingdon County published in 1885 the bed at Dudley being considered Kelly, the four-foot bed higher in the series was thought to be a new bed entirely and the name "Dudley" was applied to it. (See Vol. T 3 p. 46.) But the name has not been used subsequently because it was there applied to what is now known to be the true Kelly bed. The same name, however, is applicable for the bed at Dudley.

The following is a measurement taken at the head of a drift on the Dudley bed, on the west side of the railroad just south of Dudley:—

SECTION OF DUDLEY BED.

	Ft.	In.
Shale roof		
Coal,	0	5
Shale, coal, and bone,	2	0
Shaly coal,	0	2
Hard, flinty clay,	0	6
Coal and bone,	1	0
Under-clay,	1	0
Sandy shale.		

The entire section from the Barnett bed up to the Kelly bed is greatly thickened on Shoup's run reaching its maximum in the vicinity of Dudley; here it is over 250 feet. It is in this territory of thickened interval that the extra coal beds are found, including the Barnettstown and Dudley beds. Some argue that such an interval is too great to be true and that the bed 250 feet or more above the Barnett south of Shoup's run cannot be Kelly. But the proportion of the thickening of the interval from 100 feet on Six Mile run to 250 feet on Shoup's run is not inconsistent with various other changes in interval in the Broad-Top field; for instance, on Six Mile run at the old Wigton or Cunard workings, the Barnett was found within 10 feet of the Fulton whereas about one mile from there at the old Scott shaft a section by John Fulton shows a thickness of 70 feet between the Fulton and Barnett. In the East Broad-Top basin the same interval varies from 30 to 90 feet.

THE KELLY COAL BED.

The Kelly coal bed, according to Mr. A. J. Black, who has been allied with coal mining in Broap-Top foi many years, and who was reared on the monntain, takes its name from a man named Barney Kelly. This statement was made to Mr. Black by his grandfather, Mr. W. W. Edwards. In the early history of mining, as has been brought out nnder the subject "History of the Field," the Cook bed (Fulton) at Broad-Top City was thought to lie above the Barnett and was correlated with the so-called Kelly. The name Kelly spread from here to Six Mile run and Sandy run where it was applied to the third workable bed above the Pottsville, a true situation that has preserved the name. But the Cook or Kelly bed at Broad-Top City was naturally replaced by the name Fulton, to avoid all confnsion, after it proved to lie below and not above the Barnett.

The Kelly coal bed has been extensively mined on Six Mile run, Long run and Sandy run, as may be seen by a glance at the sheet showing the extent of underground workings on this bed. It varies from three to four feet as shown on the accompanying colnmnar section sheet.

The area of the Kelly coal is more limited than the area of Fulton and Barnett. It is higher in the series and has snffered the effects of erosion to a greater extent that the lower beds. It has been heavily drawn upon in mining, bnt its persistent nature indicates that it will yet furnish a large amonnt of recoverable coal. It has a black shale or shaly sandstone roof and a variable under-clay ranging from zero to three feet in thickness. For a discussion of its comparative valnes see heading "Character and Quality of the Commercial Coals."

THE SPEER COAL BED.

The name Speer has come into common use for the first bed above the Kelly; it lies between two divisions of the Mahoning sandstone and ranges from one to two feet in thickness. Occasionally the name "Kelly Twin" is used for this bed but it lies about 50 feet above the Kelly, hence cannot be mined with it. Other small beds still higher above the Kelly are sometimes incorrectly referred to as the Speer. In fact the bed of the Langdondale and McCue basins that lie 260 feet or more above the Kelly is called locally the Speer. Miners are apt to apply the name to the first thin bed exposed above the Kelly. This is usually the true Speer bed, in the Mahoning sandsone. It corresponds to the Mahoning coal in portions of the Bituminous Basin.

The Speer bed is persistent and can usually be found in its proper position above the Kelly. Its thickness averages about fifteen inches, thongh it has been reported that on lower Six Mile run it has been found to show a local thickness of three feet, but impnre and slaty.

THE PHIPPS COAL BED.

In Wilson basin on Six Mile run, at the south limits of the workings of the Duval slope, a bed is exposed about 30 feet above the Speer bed. It has been opened near the Phipps residence a few hundred yards above the mouth of what is known as Mosquito Hollow; this branch of Six Mile Run leads eastward from a point between Defiance and Coaldale. At the Phipps opening the coal shows two feet four inches of clean coal with a shale roof and floor. This is an abnormal thickness, however, as the bed appears to quickly thin away and like other beds of the Conemaugh group can not be depended on, even locally. It was not measured elsewhere.

THE MOSQUITO-HOLLOW COAL BED.

The Mosquito-Hollow coal bed is a thin bed in the Conemaugh that outcrops on the steep hillside above the Phipps mine in Mosquito-Hollow, near its junction with Six Mile run. At this point the bed is about ten inches thick. A greenish-gray shale lies between the bed and the Phipps bed. This bed was not seen elsewhere, there being practically no other natural exposures at this horizon in the field.

THE McCUE-BASIN COAL BED.

The McCue-Basin coal bed is named by the writer from exposures in the McCue Basin on Sandy run. The bed ranges from one foot to local thickenings of about three feet. The bed was at one time opened a short distance north of the mouth of Long run where it lies in the bottom of the McCue-Basin fold rising quickly to the surface on the two flanks. It has been prospected also on the hill-side above the road south of Stone Row in the same basin.

The McCue-Basin bed occurs only in limited districts where the higher rocks have been caught in deep folds or have remained in knobs. The bed is exposed by the road-side in the Langdondale Basin just above the Langdondale shaft. It is here about 270 feet above the Kelly. At the latter point it is covered by an exposure of thirty feet of sandy shale at the top of which is a streak of black coaly shale. Beneath the McCue-Basin bed a similar sandy shale is exposed in the upper portion of the Langdondale shaft. This shale can be traced over the anticline west of Langdondale and into the McCue-Basin where the coal appears again; the McCue-Basin coal has been eroded from the crest of the anticline between the two basins. The confusion of the McCue-Basin coal with the Pittsburgh bed that lies over 500 feet above the Kelly has led to an exaggerated idea of the depth of the McCue-Basin.

THE ROGERS COAL BED (PITTSBURGH).

At five known points in the Broad-Top field, as shown on the geological map of the field, the Rogers or Pittsburgh bed, is known to outcrop. These localities are near the tops of high knobs where patches of rocks high above the Kelly bed have been preserved. In the report on Huntingdon County and the report on Bedford and Fulton Counties, Volume T 3 and T 2 respectively of the Second Geological Survey of Pennsylvania, this bed was correlated with the Pittsburgh bed. While the evidences of this correlation are based purely on the character of the coal and the interval above the Mahoning sandstone, it is quite probable that the identification is correct. However, it has been found that the interval from the Upper Freeport coal to the Pittsburgh bed thickens in going eastward across the Bituminous Basin so that if this thickened interval remains constant the Pittsburgh bed would, according to Dr. G. H. Ashley, be found some 900 feet above the Kelly (Upper Freeport) rather than slightly over 500 feet.

Near the Rogers residence, on the high knob of the Mt. Equity mine on six Mile run, this bed has been opened in a short drift. This is the only point in the Broad-Top field where the coal is open for inspection. The section of the bed is as follows:—

SECTION OF THE ROGERS COAL BED.

	Ft.	In.
Shale, dark thin-bedded		
Coal, bony,	1	5
Coal with well developed vertical cleavage in a massive block,	2	0
Coal,	0	4
Shale,	0	0¼
Coal,	0	6
Underclay,	4	3¼

Regarding the nature of this coal in comparison with the typical Pittsburgh coal of the Bituminous field, Mr. Richard R. Hice, State Geologist, who made the above section has this to say:—

"There would seem to me but little room to doubt the correlation of the Rogers with the great Pittsburgh coal. While the interval between the Kelly (Upper Freeport) coal and the Rogers is less than the interval between the same horizon in the Johnstown or Ebensburg quadrangles, it corresponds closely with the usual interval.

"In Beaver County this interval is about 575 feet; in Westmoreland County it is some forty feet less. It has been thought by some, on the strength of the greater interval in the Johnstown and Ligonier region, that the Rogers coal belongs in the Conemaugh series. When the trough at Ligonier is followed southwest into West Virginia we find at Newburg, Preston County, a thickness for the Conemaugh of 645 feet; but when we pass 50 miles eastward, to Fairfax Knob, Tucker

County, this interval is but 538 feet (I. C. White, Bull. U. S. Geological Survey No. 65) which very closely corresponds with the Broad-Top interval, and we should expect a correspondence with the Tucker County locality, rather than with the Ligonier or Johnstown regions which lie across the basin from Broad-Top. The differences in the interval are what should be expected, and are in harmony with the general conditions which attended deposition in Carboniferous time.

"In both Pennsylvania and southward in West Virginia the interval is greater towards the axis of the Bituminous Basin than on either the western or eastern side.

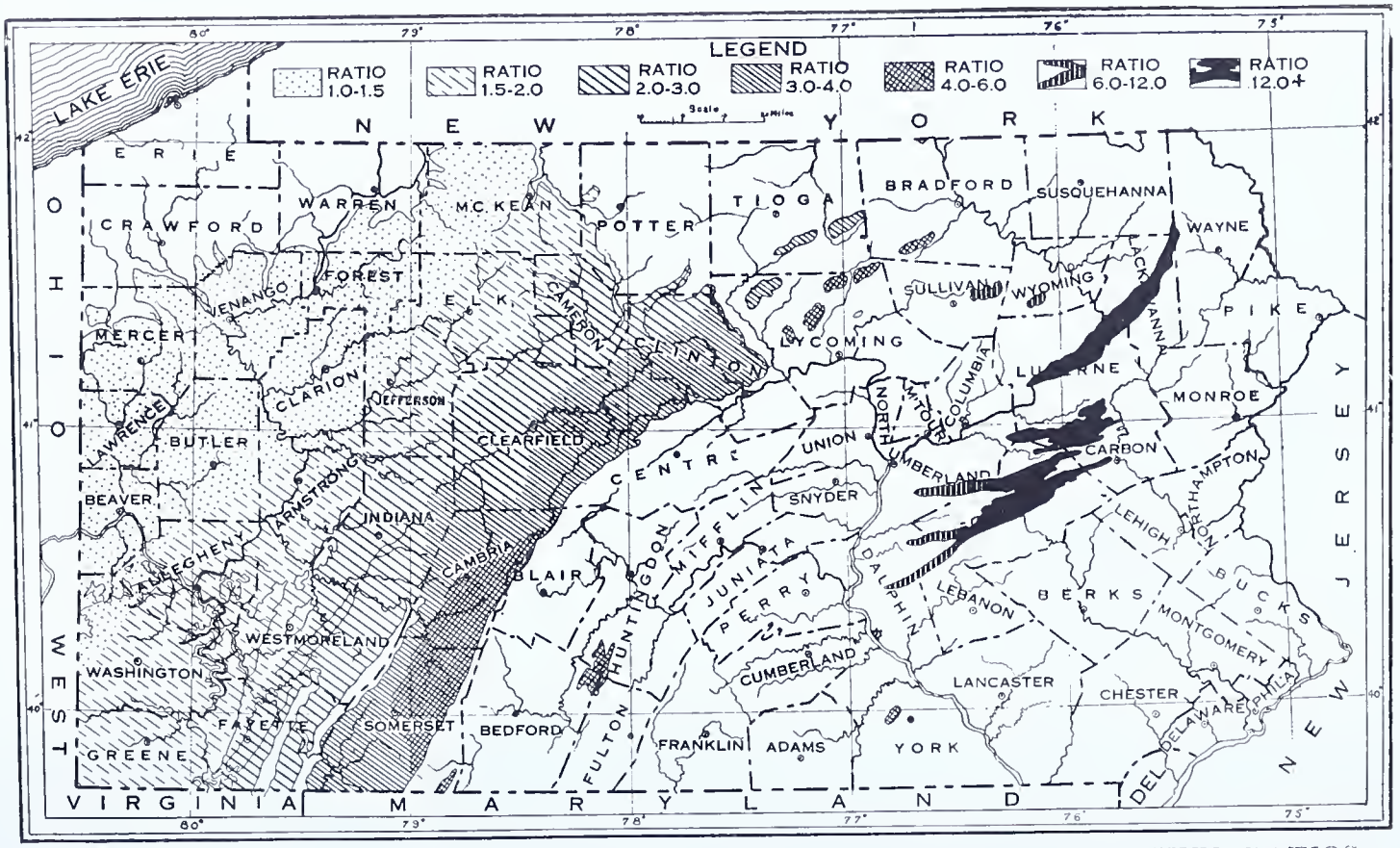
"In addition to the interval it must not be forgotten that above the Rogers coal we find limestone beds, which from the fragments seen appear to be of fresh water origin and so far as observed entirely non-fossiliferous. The thin coals found between the Rogers and the Kelly coals seem to occupy a proper horizon in view of the interval.

"The character of the coal as seen at the opening near the Roger's house at once points to its being the Pittsburgh. The internal structure is characteristic of the main bench of the Pittsburgh, and while there was no break in the roof to show whether the roof coals were present or not, the roof shales are quite carbonaceous. There is no natural exposure of the coal. The thin shale or slate parting given in the section is not to be overlooked. It was noted as constantly present, and on inquiry the miner stated that a second parting was frequently present, about four inches above the one seen.

"The more the coal itself is examined, and the more the whole interval downward to the Kelly (Upper Freeport) is studied the more certain it appears that the correlation heretofore made with the Pittsburgh bed is correct."

COAL ABOVE THE ROGERS BED.

The writer was not able to find any coal outcrop or exposure above the Rogers or Pittsburgh coal bed; but in the report on Bedford and and Fulton Counties, Vol. T 2, Stevenson mentions the fact (p. 249) that Mr. Wigton once prospected a bed that lies 235 feet above the Rogers bed. This bed is sixteen inches thick and consists of very poor coal.



MAP OF PENNSYLVANIA, SHOWING DISTRIBUTION OF COALS BY FUEL RATIOS.

PLATE XXVII.

CHARACTER AND QUALITY OF THE COMMERCIAL COALS, WITH NOTES ON ANTHRACITIZATION.

The coal of the Broad-Top field falls into the class known as semi-bituminous, between semi-anthracite and bituminous. This classification is based on the fuel ratios of the analyses. The fuel ratio is obtained by dividing the percentage of fixed carbon by the percentage of volatile combustible matter and is a well-known method of classification; it was first adopted by Prof. Persifor Frazer in 1876-77 when he prepared a report on "The Classification of Coals" issued by the Second Geological Survey of Pennsylvania in 1879. (Volume MM pp. 128-144).

In this paper he suggested that the coals from anthracite to bituminous be classified as follows on the basis of their fuel ratios,—"Anthracite (100 to 12); semi-anthracite (12 to 8); semi-bituminous (8 to 5); bituminous (5 to 0). Limiting the maximum ratio of anthracite at 100 and the minimum for bituminous coal at zero was, of course, in error, since coal passes into graphite at the upper extreme and down into lignite at the lower extreme. But in its broader aspects this scheme came into usage. Ashley has suggested, however, that present trade usage would probably make semi-anthracite from 10 to 6 and semi-bituminous from 6 to 4 or possibly 5 to 3. On this basis Broad-Top coal falls into the class of semi-bituminous, ranging on a general average from 3.7 to 4.5 as do some of the coals of the eastern margin of the Bituminous Basin proper and the coals of northwest Maryland. While this method of classification has been justly criticised so far as details are concerned, it is simple and in the main correct.

Plate No. XXVII of this report is a small map of Pennsylvania showing the distribution of coals by fuel ratios. In connection with this map the following valuable and interesting data is quoted from the report of the Topographic and Geological Survey of Pennsylvania 1906-1908 pp. 223-224. Both the map and the material quoted were prepared by, or under the direction of, Dr. George H. Ashley of the U. S. Geological Survey in co-operation with the State.

"An attempt has been made on Plate No. XXVII to indicate the distribution of the various grades of coal in Pennsylvania on the basis of the fuel ratios. Examination of the map shows the anthracite coal of Lackawanna, Luzerne, Carbon and Schuylkill Counties to have a fuel ratio averaging over 20, the analyses showing from 80 to 88 per cent. of fixed carbon and from 3 to 4.5 per cent. of volatile matter. The western ends of those fields tend to grade into the semi-anthracite class. In eastern Sullivan is the Bernice field of 'soft anthracite" or semi-anthracite, with a fuel ratio of 6 to 10. This field contains coals that run over 80 per cent. of fixed carbon and under 9

per cent. of volatile matter, 83.4 of fixed carbon and 8.10 of volatile being a typical example. On the other hand most of the analyses on hand from the Bernice Basin show a fuel ratio of between 3.5 and 6. Then comes the Broad-Top field of Bedford and Huntingdon Counties, and a strip along the Allegheny Front, where the rocks, if not more folded than farther west, have probably been subjected to much greater stress.

The rocks west of the Allegheny Front seem to have served as a buttress against which the rocks to the east were folded and it is natural to suppose that the face of this buttress should suffer more severely than the rocks farther back. The folding is not always more noticeably pronounced close behind the front, but in Clearfield County, at least, mining has brought out the fact of extensive thrust faulting and all of the coals near the face tend to be minutely dissected with fracture planes, making the coals tender and soft, so that there is found from Bradford County a strip running through Lycoming, Southeast Clearfield, Eastern Cambria and Somerset Counties, where the coals have a fuel ratio of from 4 to 5.

At South Fork in Cambria County the fuel ratio runs close to or quite to 6. West of that through the same counties, and extending over into Tioga and Clinton, the coals show fuel ratios of from 3 to 4. Coming between 2 and 3 will be found the coals of the Allegheny or Lower Coal Measures in Blair, Clinton, Indiana, Westmoreland and Fayette Counties, and part of the Pittsburgh coal, though only that portion in the basin immediately west of Chestnut Ridge, where it has been involved in relatively close folding.

It is noticeable, for example, in Indiana County that while the Pittsburgh coal in that county will run about 1.6 the Allegheny coals will run from 2.5 to 3. The Connellsville coking coal of Westmoreland and Fayette Counties will, as a rule, run about 2, sometimes reaching as high as 2.5. As a rule, however, the Pittsburgh coal will run between 1.5 and 2. In addition to the Pittsburgh coal most of the coals of Potter, McKean, Jefferson, Armstrong, Butler, Allegheny and Washington Counties will run between 1.5 and 2. The coals lying still farther to the northwest in Clarion, Mercer, Lawrence and Beaver, will run between 1 and 1.5.

On the map the different symbols have not been drawn as sharp boundaries nor are they intended to indicate the exact limits of the areas in which the different ratios hold, but only the approximate limits. In many areas the data is meager or wanting, and only a preliminary study of the matter can be presented. In many cases analyses from the same district will show a marked difference in the fuel ratio, as has already been cited in the case of the Bernice semi-anthracite field. In most of these cases the plan has been followed on the map of indicating the higher fuel ratio where that appears to be predominant."

The coal of the Broad-Top field is tender and soft. It is dissected by numerous fracture planes and easily breaks down into fine coal. It is very black and as a result of folding is thoroughly slicken-sided along fracture lines giving it a very bright appearance. The coal in the zone of intense folding in the West Broad-Top Basin is thoroughly crushed so that in mining a large portion is recovered as fine coal. But it is all sold as "mine run" throughout the field.

In the East Broad-Top Basin and on both flanks of the Broad-Top arch a larger percentage of block coal is recovered. Plate XXIX, Fig. 1, indicates the general appearance of the East Broad-Top coal as loaded on mine cars, but its tender nature is at once revealed in the loading and rehandling. In diamond drilling over most of the field it is very difficult to recover a good core of 2 inch diameter. Some years ago considerable drilling was done on the East Broad-Top side with a diamond drill of three-quarter inch core, but the results are absolutely unreliable, as has later been demonstrated by underground workings in the vicinity of Woodvale.

Along the crests of the steep anticlines of the West Broad-Top Basin on Six Mile run, Long run and Sandy run especially the coal is badly crushed. But all of it is good fuel and is mined at all points except where "squeezes" have made the working of the bed unprofitable. The crushed coal comes from the mine as fine as ordinary "slack" coal, but is sold "mine run" with the rest. It is probable that this character of coal would briquette with a minimum of binder and produce a splendid, uniform and easily handled fuel for domestic use. Experiments and investigation along this line by operators in the field would likely be justified.

The question as to why the Broad-Top coal has been subjected to such intense folding, without the production of a fuel more nearly approaching anthracite, opens a field of discussion involving several factors.

Compression in the Broad-Top field while not so intense as that of certain portions of the anthracite district of the State, is nevertheless comparable. In Broad-Top none of the folds are overturned and they are more regular than in the hard-coal district. The structure sections accompanying this report are drawn on the same vertical scale as the horizontal, thus giving the natural proportions. Numerous published sections of the hard coal region show the vertical scale out of all proportions and this fact should be noted by the reader in making comparisons; to increase the vertical scale as related to the horizontal is to produce the same optical effect as greatly increased compression in folding by which the section is shortened laterally. But a comparison of the two districts reveals the facts that there is a general similarity in structure, both districts lying in the belt of Appalachian folding.

Regional metamorphism, due to lateral pressure accompanying the Appalachian uplift and compression, has caused a gradual increase in the quality of coal as the axis of that great structure is approached across the Appalachian Coal-field at any point. As from Ohio and Western Pennsylvania the coals show a gradual increase in the percentage of carbon eastward to the Allegheny Mountains, just so it is true in passing from Indiana across Ohio into West Virginia or from Western Kentucky eastward to the Cumberland Mountains. There are, of course, local inconsistencies in this transition brought about by variation in structure and fundamental character of the coal. But this does not explain why the coals of the Broad-Top field, which lie east of the Allegheny Mountain, have not been metamorphosed as have the coals of the Northern Anthracite basin, for instance, that lie in the same general depression.

David White has advocated that local folding accompanied by more or less "squeezing" or faulting such as is found in either the Anthracite field or in the Broad-Top field releaves the effects of pressure and causes the retention of volatile contents rather than increasing devolatilization. He points out the fact that coals often show a higher volatile content in folded and faulted rocks than in contiguous areas "where a stress, presumably less intense, was endured for a longer period." The loss of volatile matter in the anthracites of Pennsylvania was credited by J. P. Lesley to pressure acting jointly with the porosity of overlying rocks and to jointed structure. But the rocks of the Broad-Top field are of a similar nature and jointing is even more extreme than in the Anthracite field. White attributes the cause of the joints to the same horizontal pressure that caused the escape of volatile matter which is unquestionably correct.

It has been held by some that anthracitization depends not altogether on the effects of dynamic pressure but also to a large extent on the original nature of the coal as dependent on atmospheric conditions and bacterial action or in physiographic conditions attending deposition. While these conditions naturally have played their parts in the nature of the original coal, they can not account for the various geographic differences in grades of coal. They only effect the original substance on which dynamic agencies are later brought to bear; a lignite originally high in its percentage of ash, for instance, will necessarily produce by metamorphism an anthracite high in ash, etc.

The writer believes that coal in the Anthracite field was more thoroughly metamorphosed than in the Broad-Top region, because the coal beds lay at a much greater depth below surface at the time of folding. In the deeper Anthracite basins, there are 3000 feet or more of coal measures, excluding the Pottsville, while it can never be known what thickness of rocks have been eroded above the top.

In Broad-Top some 1200 feet carry the section well up toward or into the base of the Permian where again the matter of estimating the amonnt of erosion is indefinite. At some points in the Anthracite field the Pottsville is 1200 feet thick whereas it is about 300 at best over Broad-Top, all of which indicates that the amount of deposited sediment to the north was much greater. It would appear that the sediment carrying agencies from the land areas deposited their materials more extensively in the northern territory and it is quite probable that the load was greater there at the time of the Appalachian uplift than in the Broad-Top or along the eastern rim of the Bituminous field.

If this were the case, then the coals being at deeper levels would suffer greater heat and pressure through a longer length of time. In addition to the thrust pressure would be the pressure produced by the load where the cover was great, while areas subjected to the same pressure at points of less cover would have less load and more opportunity for the relief of pressure through buckling, fracturing and conduction of heat to the surface. The more solid, compact, schistose structure of anthracite, regardless of its analysis, indicates that it has been compressed under conditions wherein pressure and resistence were nearly equal in all directions. The jointing in the Broad-Top coals (See Plate XXVI, Fig. 3) indicates that the coal was affected by movements of uplift and compression, the vertical joint fractures permitting upward relief of pressure.

It is easily conceivable that if folded under a greater depth, the coal of the Broad-Top field would have taken up pressure not through crnshing but through increased density at the expense of volatile matter which would pass out and be absorbed into the porous rocks. In addition to these factors the transmission of pressure through thrust stresses attending the Appalachian uplift were probably greater in the Anthracite field than farther south.

The table of analyses of Broad-Top coals submitted with this report is made up from various sources as indicated thereon. Practically no ultimate analyses are available but the proximate contents and fuel values are clearly set forth. The coal is popular as a steam fuel being consumed in the eastern portion of the United States and on Atlantic steamers. There is very little difference in the fuel values of the Fulton, Barnett and Kelly coals. The local variation in any one bed is as great as the difference in any two of the beds. The Kelly bed usually shows less sulphur than the other two, while the Barnett tends to run highest. They range from 14,000 to 15,000 in B. t. u. heat value with quite a variable ash percentage in the commercial coal. All three of the beds will coke satisfactorily but for this purpose the Kelly and Fulton are better than the Barnett as brought out under the heading "Coke."

In the old Zeth and Dodson mine on Sandy run at the mouth of Long run a very peculiar coal was encountered at the top of the Kelly bed in a portion of the workings. Such coal does not occur elsewhere in the field. This material has the appearance on first inspection of being ordinary black coal slicken-sided by pressure. Numerous pieces of it lie upon the dump. It came to be known as "glass coal" and was rejected from the commercial coal on account of the fact that it will not ignite and burn as ordinary coal. It mines out in the form of small prismatic pieces that are exceedingly black and bright along the faces. The specific gravity is considered greater than ordinary Broad-Top coal or anthracite. Pieces were collected by the writer that had lain for several years on the dump without showing any effects of weathering. This is a variety of coal in which the percentage of ash is as high as the volatile matter, yet it contains more than sixty per cent. carbon. Calculated on the basis of ash-free coal it corresponds to the ordinary Kelly coal at the Mt. Equity mine in the same basin. The following analyses are interesting:—

ANALYSES OF HIGH ASH COAL FROM ZETH AND DODSON MINE.

	High-ash coal as analyzed.	Kelly coal, Mt. Equity mine; as analyzed.	High-ash coal as ash-free.	Kelly coal, Mt. Equity mine; ash-free.
Fixed carbon,	62.22	73.86	77.39	78.07
Volatile matter,	18.17	20.72	22.61	21.90
Ash,	19.61	5.42	.....	.....

It will be noted from the analyses above given that a coal originally very high in ash, or "bone coal," is metamorphosed just about the same as ordinary coal.

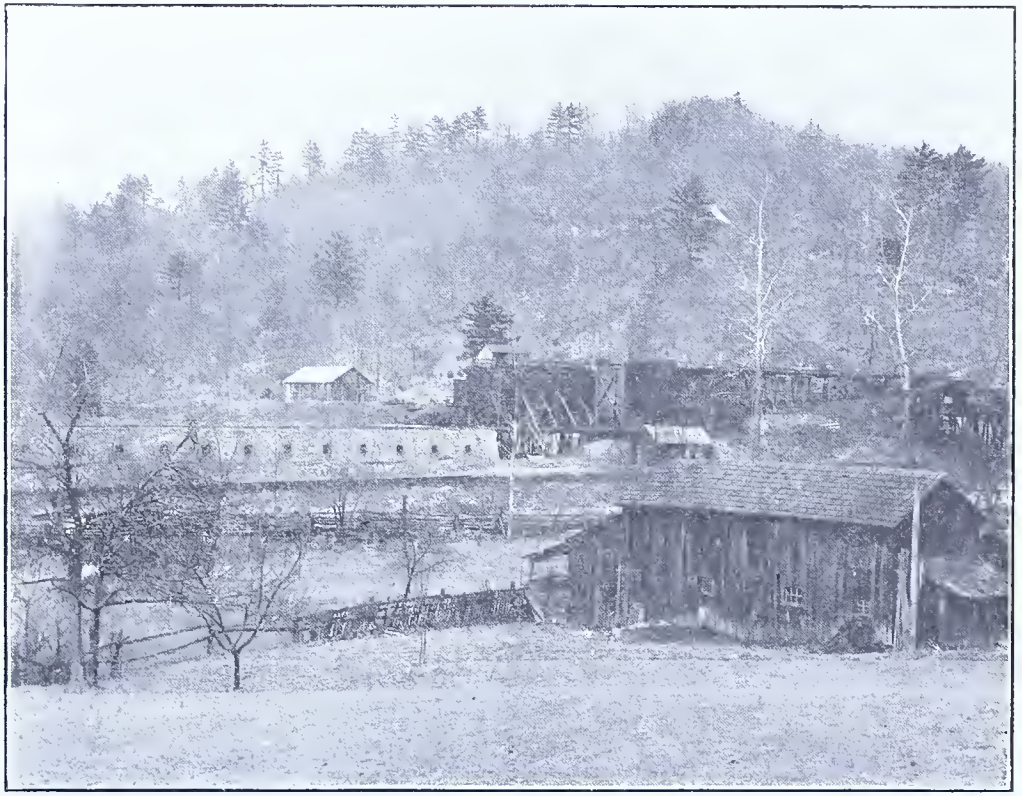


PLATE XXVIII.

Figure 1. Looking northward across Shoups Run toward the Miller Mines, showing Thropp's coke ovens on the left.

PLATE XXVIII.

Figure 2. Coke ovens of Colonial Iron Company at Riddlesburg.

COKE.

The three commercial beds of the Broad-Top field, the Fulton, Barnett and Kelly, are all coking coals. The Barnett, however, is not coked at the present time and is said to make a coke inferior to either the Fulton or Kelly. This is due to its being slightly higher in sulphur. The Kelly coal is usually lowest in sulphur and is preferred for coking though its value for this purpose over the Fulton is slight.

There are six coking establishments in the Broad-Top field, which with the number of ovens at each and the operators are as follows:—

COKE OVENS IN BROAD-TOP FIELDS.

Operator.	Location.	Number of Ovens.
Joseph E. Thropp,	Wigton or Cunard mine,	18
	Minersville,	90
Rockhill Iron and Coal Co.,	Orbisonia,	132
Joseph E. Thropp,	Kearney mines,	170
	Saxton,	152
Colonial Iron Co.,	Riddlesburg,	168
Total number of ovens,		730

In 1912 the first three of the above listed plants were idle; the remaining ones produced 251,346 short tons of coke all of which was consumed at the local furnaces mentioned. The coke is made from unwashed run-of-mine coal and manufactured in ordinary beehive ovens with the exception of those of the Rockhill Iron and Coal Company at Orbisonia which are of the Belgian type.

Broad-Top coke is considered very good for iron furnace use. It is reasonably bright, tenaceous and strong. It carries the ordinary load of ore charges without crushing. It is not so open and uniform nor so fibrous and bright, however, as Connellsville coke. The following table of analyses shows the comparison of Fulton and Kelly coke with that from the Connellsville region:—

ANALYSES OF COKE.

	Fulton coke, Robertsdale, mixed from mines B and C.	Fulton coke, Robertsdale mine C.	Kelly coke, Mt. Equity mine.	Kelly coke, Cambria mine. Pit-coke.	Connellsville H. C. Fricks works.
Water,	.350	.400	.95	1.01	0.030
Volatile matter.	.930	.750	.57	2.29	.460
Fixed carbon,	88.136	88.162	89.08	86.78	89.58
Sulphur,	1.824	1.318	.925	1.93	.82
Ash,	10.760	9.370	9.32	7.98	9.11

The above analyses were made more than twenty years ago and the analysis of Connellsville coke was published by John Fulton ; being a fair average as analyses were made at that time.

The first coke manufactured in the Broad-Top field was made from Kelly coal for use in connection with the remelting of iron at the old Hopewell furnace about 1846. This coke was made in open pits from coal mined on Sandy Run in the vicinity of the old Chevington mine; but only a very limited amount was used at that time and then only in open fires. At that time charcoal only was used in the furnace.

MINES AND MINING.

On the geologic map accompanying this report there are located about one hundred and forty mine openings. In a number of cases several of these mines are operated by, or under control, of a single company in which case they properly compose a colliery. In other cases the openings represent abandoned or closed workings. Many of these are small prospects, drifts or slopes that were abandoned by the operators in order to open the coal near by at some more favorable point in the structure, after the "lay" of the coal was determined. The following is a list of the operators and collieries of the field:—

LIST OF OPERATORS AND OPERATING MINES IN BROAD-TOP COAL FIELD DURING THE YEAR 1912.

ROCKHILL IRON AND COAL COMPANY, ROBERTSDALE, PA.
Robertsdale slopes No. 1, 2, and 3 and Woodvale shaft.
JOSEPH E. THROPP, EVERETT, PA.
Gordon mine, Melrose No.'s. 1, 2 and 3;
Kearney-Barnett, and Kearney slope.
JOHN LANGDON, HUNTINGDON, PA.
Duval slope, Cambria No. 2;
Glendale No. 1, and Glendale No. 2.
COLONIAL IRON COMPANY, RIDDLESBURG, PA.
The Judith mine.
E. EICHELBERGER AND COMPANY, SAXTON, PA.
Bacon and Daugherty mines.
MT. EQUITY COAL AND COKE COMPANY, SUNBURY, PA.
Mt. Equity No. 1 and No. 2.
CARBON COAL AND COKE COMPANY, No. 85 DEVONSHIRE STREET, BOSTON, MASS.
Carbon No.'s. 1 and 4; Ocean No's. 2, 3, 4 and 5;
Langondale shaft (Cambria No.3).
SCHIPPER BROS. COAL MINING COMPANY, SIX MILE RUN (COALDALE), PA.
Bartle No's. 2 and 3; Cuba No. 1; Ladysmith No's. 1, 2 and 5;
Illinois No's. 3 and 4.
JAMES M. McINTYRE AND COMPANY, SIX MILE RUN (COALDALE), PA.
Shreeves Run Mine. (Finleyville).
HUNTINGDON COAL COMPANY, HUNTINGDON, PA.
Delaware No's. 1 and 2.
HIGHLAND COAL MINING COMPANY, REAL ESTATE TRUST BUILDING, PHILADELPHIA, PA.
Highland No's. 3 and 4.
SAXTON COAL COMPANY, SAXTON, PA.
Brown mine. (Kenmar).
LOUISE COAL COMPANY, CHAMBERSBURG, PA.
Rock-Bar Barnett and Rock-Bar Kelly.
M. V. ZETH AND COMPANY, HOPEWELL, PA.
Cambria No. 5.
BROAD-TOP COAL AND MINERAL COMPANY, JACOBS, PA.
Jacobs-Fulton and Jacobs-Barnett. (No's. 1 and 2).
ROCKY RIDGE COAL & COKE COMPANY, HUNTINGDON, PA.
Wrays Hill Mines (Rocky Ridge No's. 1 and 2 and Victoria openings.)
Starr No. 1.
SHANNON COAL COMPANY, SAXTON, PA.
Martha No's. 1, 2 and 3.

In addition to the above mines that were operated in 1912, there are numerous idle and abandoned mines shown on the map and listed

thereon by corresponding numbers. The list of operating companies as given above is complete for the whole field with the exception of country mines supplying local trade only. The name of the beds worked at the different mines can be secured by noting their locations on the map with respect to the outcrop lines except in case of the two shafts; the Langdondale shaft is to the Kelly bed and the Woodvale shaft to the Fulton.

Most of the mines of the Broad-Top field are operated on a comparatively small outlay of capital. To a considerable extent local money and talent is in use and the leasing system is largely adopted. On the East Broad-Top side the Rockhill Iron and Coal Company has control of the entire situation, owning the Trough Creek Basin and operating the mines at Robertsdale and Woodvale on the East Broad-Top Railroad. Their mines are laid out on a better system than any other in the field, because of the fact that the measures are not so closely crumpled as on the West Broad-Top side. Their output being some 1300 tons per day is the largest in the field. Haulage is by steam and their plants are modern.

There is an absence of what might be termed up-to-date plants and methods in the Broad-Top field as a whole. This is due largely to the fact that many of the operations are comparatively small and knowledge of structural conditions in advance of mining rather uncertain. Practically no electric haulage is used. One electric motor operated within the Kearney mine and electric motor-haulage in the Cambria No. 3 mine (Langdondale shaft) are exceptional. In one or two cases small electric power is generated to drive pumps.

In other instances compressed air is used for this purpose. At one mine a small gasoline motor was being tested with only fair results, the objection being that its initial power in starting a load up grade was limited. Most of the haulage in the larger mines is by means of steam with head and tail rope. In some of the smaller operations mules pull the coal to the tipples. In one small mine mules are used to pull coal up the main slope that is so steep two good mules are required to draw up one ordinary-sized mine car. But in the main, steam haulage and fan ventilation, characterize the operation of the field.

The coal is tender and soft, being mined almost entirely by pick and by light charges of powder. Punching machines are not necessary though in one or two mines they are used for local areas where the coal is solid.

The general methods of mining in the Broad-Top field are naturally more closely comparable to the methods in the Anthracite District than those in the Bituminous Basin, on account of similarity of structure. The coal lying as it does in steep basins necessitates considerable variation from the ordinary pillar and breast system of mines

PLATE XXIX.

Figure 1. Mine cars loaded with coal drawn from Robertsdale slope of Rockhill Iron and Coal Company. Crushing is not so evident here as on the west side of the field.

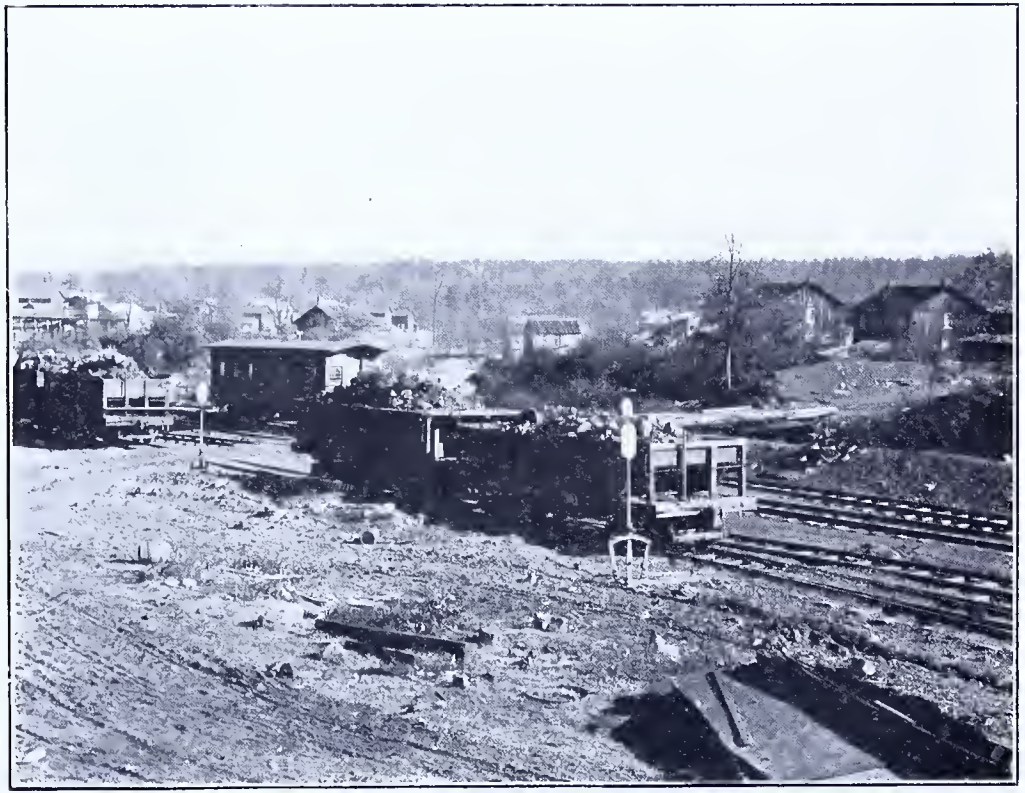


PLATE XXIX.

Figure 2. Looking northeastward from Robertsdale. Note the long, even slope of the Pottsville rising eastward on the flank of the Through Creek Basin.

PLATE XXX.

View of plant at Woodvale shaft, Rockhill Iron and Coal Company.

in horizontal beds. The details vary somewhat with the different districts on account of variation in the structure. The inclination of the coal bed in a mine may vary from horizontal to as much as sixty degrees, or may even be vertical; but as a rule the coal is mined in "pitch workings" of some degree in nearly every part of the mine. The usual method of development is by slope, the coal being drawn up an incline to the tipple, or tram-road, by means of a head-rope. A slope may enter a basin from the outcrop on the flank of an anticline, being driven down the dip with gangways leading off on either side, or it may enter the basin longitudinally. In the first case, if the mouth of the slope is located on a hillside at a considerable elevation above a nearby water-course, down the slope at a corresponding level a gangway is cut through to daylight affording an open water-level. At other points drifts from the surface are run in from the outcrop on water-level along the strike of the bed, after which mining proceeds by pillor, breast and heading in the usual manner.

In the case of shafts, the methods are the same except the shaft is located in the center of the basin and the main gangways run in either direction along the bottom of the synclinal trough, with headings to the rise on either side. In the case of mining in gangways or counter gangways on the west side of the field where the beds are very steep wooden shutes are constructed to allow the coal to slide by gravity down to the haulage ways. Irregularity of the folds interferes with drainage and haulage, compelling zigzag curves in the gangways.

In some cases where the Twin coal bed lies 8 or 10 feet above the Barnett, and is as much as two feet in thickness, it is mined locally within the mine on the Barnett by means of dropping the coal through holes cut up through the roof of the Barnett, which in that case is the floor of the Twin bed.

The general outlines of the underground workings of mines in the steep basins of the West Broad-Top field, are relatively very long for their width. The mines are often limited by the steep anticlines that bound the basin on the two sides so that working must advance chiefly by gangways lengthwise with the basin, or with the strike of the rocks.

Open lights are used throughout the field in all working. The coal is not gaseous being low in its percentage of volatile matter. Moreover the coal and overlying measures are sufficiently crushed to permit the escape of any gas that might be liberated. In the matter of explosions the record of the Broad-Top field is remarkably clear. Only two instances were noted of any explosions and these were at very local points, in one mine on Shoup's run and one on Sandy run; both are said to have been produced by "windy shots" with black powder.

There is a lack of proper development of the Broad-Top field. Many of the mining operations are small and the first impression one gets in passing through the district is that it does not show thrift. There are numerous abandoned openings where the operator with small capital has met some difficulty and, without sufficient funds to overcome it, withdrew and started another opening; this usually on another portion of the same lease or some adjacent lease. Due to the lack of funds, there is very little core-drilling in advance of development. Such absence of sufficient funds is chiefly attributable to three causes. (1) Outside capital is not secured from the anthracite operators, because they are not interested in this type of coal. (2) The bituminous operator from some other field is not accustomed to such complex structure. (3) There has not been issued heretofore any detailed map or descriptions giving the character and possibilities of the field. Hence those financially interested in the field at present are largely of local birth having taken advantage of home opportunities and have learned the best methods of extracting the coal with the least expenditure of money.

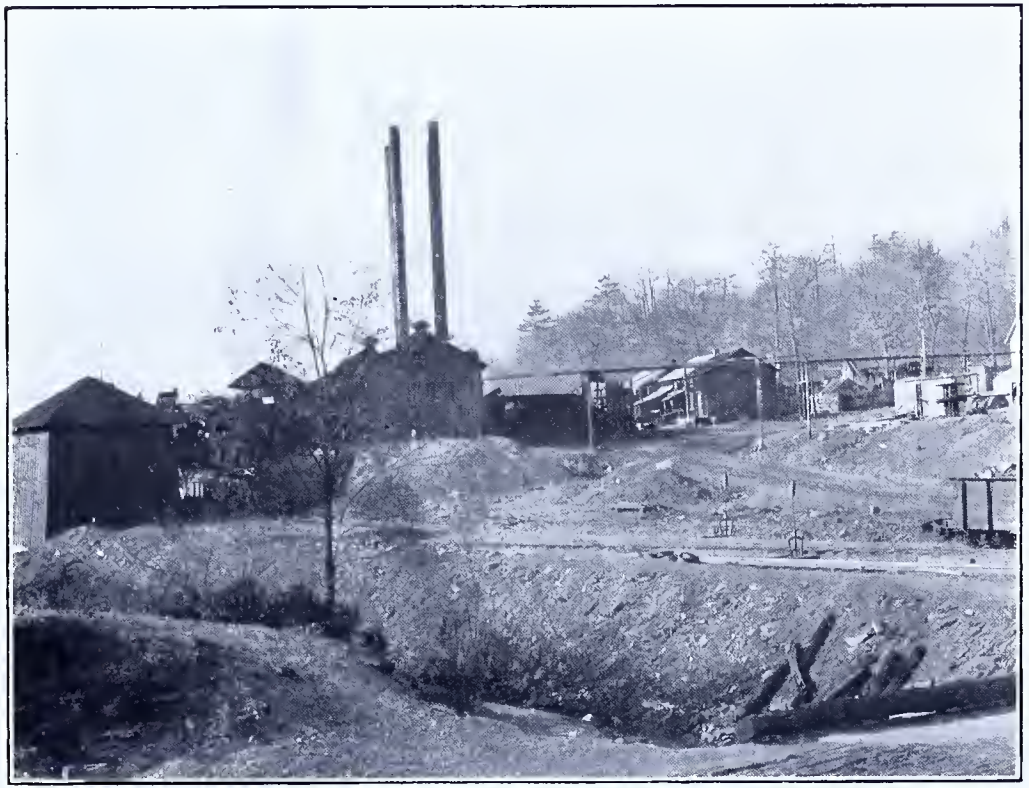
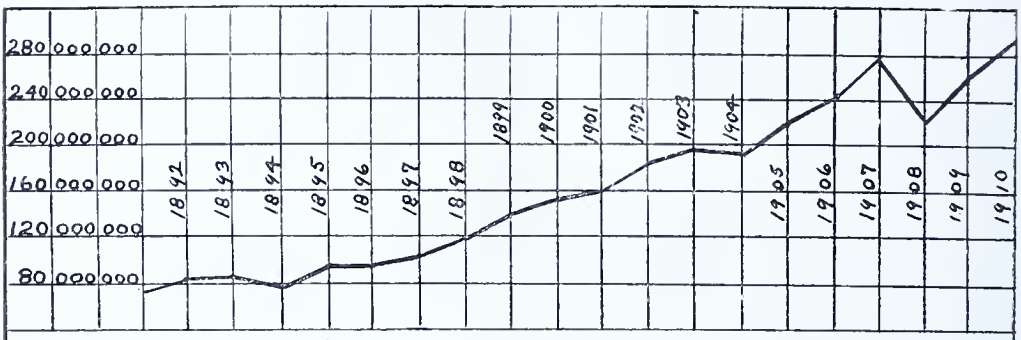
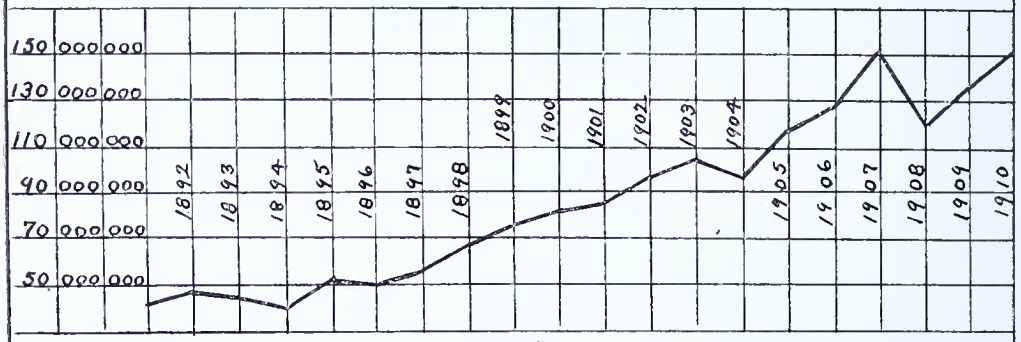


PLATE XXXI.

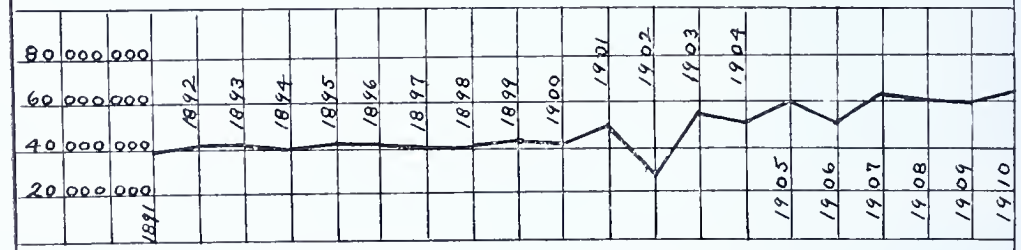
View of plant at Robertsdale, Rockhill Iron and Coal Company.



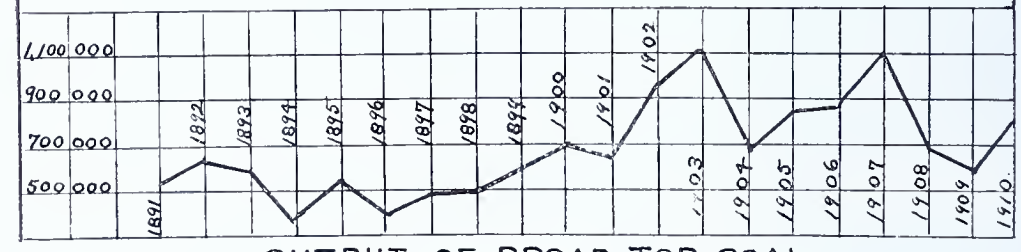
APPALACHIAN FIELD.



PENNSYLVANIA BITUMINOUS FIELD



PENNSYLVANIA ANTHRACITE FIELD



OUTPUT OF BROAD TOP COAL
SHIPPED OVER H & B.T.R.R.

PLATE XXXII.

Index showing variations in coal production.

EXHAUSTION AND POSSIBILITIES OF THE FIELD.

In the Broad-Top field, a planimeter measurement of the area of the Fulton coal bed gives 29,703 acres or 45.1 square miles.

This is the total area of the coalfield, since the Fulton is the lowest workable bed. There has been mined approximately 29,538,255 tons. The best estimate obtainable on the tonnage of minable coal left is 283,243,120 tons, which at the rate of one million tons per year will last approximately 283 years. It is of course highly probably that the rate of mining will increase sufficiently to lower this time considerably.

In estimating the amount of recoverable coal for each of the three commercial beds different percentages were deducted from the total for each bed. The Fulton was estimated to average four feet in thickness and thirty per cent was deducted as non-recoverable coal. It is the deepest bed and on the western side of the field it is probable that the intense folding has mixed the rock partings with the coal, to some extent, through crushing. The Barnett was estimated at three feet and twenty per cent figured as non-recoverable. The Kelly was figured at three feet and ten per cent deducted as non-recoverable. The recoverable coal for the three beds results as follows,—Fulton, 132,470,800 tons; Barnett, 98,409,600 tons; Kelly, 52,362,720 tons. While the percentage of deduction for the non-recoverable coal may seem small to some, it should be remembered in this connection that the amount of coal per acre in the folded belt is greater than if the beds were horizontal, and this was not considered in the calculations. Accompanying this report are three sheets which show the positions of the areas mined out and the areas left to be mined.

Mining in the Broad-Top field has been along Shoups run, Six Mile run, Sandy run and in the Trough Creek basin. It has been confined to those areas bordering railroad construction. Naturally the Huntingdon and Broad-Top Railroad has drawn its coal from the branches along the streams that lead down to the main line. Just so, the coal near the border of the basin on the East Broad-Top side has been developed. But it so happens that, especially on the West Broad-Top side, the most difficult and irregular structure in the field has been encountered. The cross-sections accompanying this report will at once make this clear to the reader. The Trough Creek basin has not suffered the close crumpling that characterizes the west side and between the two areas lies the wide, low Broad-Top arch. Practically no coal has yet been mined from this intervening territory, yet it probably offers opportunities for extensive developments. The mine in the Kelly coal bed at Finleyville is gradually extending eastward up the slope of the Broad-Top arch, and is proving the

structure regular, as the surface geology indicates. The same structure characterizes the arch across the whole field. Unfortunately the amount of Kelly coal in this territory is rathed limited on account of its having been eroded; but there is every reason to believe that the Fulton and Barnett beds are in good workable condition under the surface of the entire arch. In the vicinity of Broad-Top City the Fulton and Barnett workings have shown the structure to have a general rise to the arch. The workings of the Rockhill Iron and Coal Company have extended westward from Trough creek showing that the Fulton and Barnett beds lie beneath the arch and gradually rise to the crest on the opposite side from the Finleyville workings and those at Broad-Top City above mentioned.

At the south end of the field the surface exposures indicate that the same general regularity holds good; on that side the Wishart opening shows the Barnett bed in good condition with more than the average thickness. Over the territory lying along the head drainage of Six Mile run, Shreeves run, Long run, and Sandy run, and from that eastward over the arch including the head of Trough creek, diamond core-driling should be done to prove the thickness of the coal beds. There is no reason to think the coal is other than normal over this undeveloped field where the structure lies well for mining and for drainage.

The supply of the Kelly coal has been rather heavily drawn upon because its area lies largely along the branch lines from the Huntingdon and Broad-Top Railroad and it is the uppermost of the three commercial beds; it lies above drainage and has naturally been the first to attract mining. A branch road is being constructed southward from Coalmont in order to open the Kelly on its northern outcrop and remove a portion of the remaining area between Six Mile run and Shoups run; the coal dips southward toward Six Mile run but the old workings to the south offer large sump areas to care for water if headings are driven through; and therefore the coal can be taken out northward to Shoups run.

The area of Kelly coal south and southwest of Broad-Top City is of undetermined character. Some years ago drill holes of three-quarter inch core were put down over this area, but a core of Broad-Top coal can not be secured of so small a diameter, due to its jointed and tender nature. The underground workings at Woodvale have proven these records of practically no value, for coal has now been mined under an area where drill holes did not reveal a workable bed. More recent drilling with a two and one quarter inch core drill has given good cores, but the extreme hardness of the rocks make drilling slow and expensive. Along the eastern margins of the Kelly area the bed lies under slight cover and its character is yet to be determined.

At the head of Six Mile run no exposures were available to the writer, but some prospecting has been done about one and one half miles southwest of Broad-Top City that is reported to have revealed good coal at the Kelly horizon.

The Fulton and Barnett beds have been worked under very slight cover at the head of Shoups run and the coal was found in good condition. The evil effects of weathering under slight cover are worse with the Kelly bed on account of the massive, heavy Mahoning sandstone that lies above the coal; it weathers into huge masses that slip from their natural positions and crush the underlying bed out of proportions; but the percentage of Kelly coal lost from this source is light. Along Kimbers run a portion of the Kelly will be difficult to work on account of the excessive folding, and should in any case be mined from the Sandy Run side, toward which the beds dip as shown on the structure sheet.

The proximity of the Broad-Top coal field to eastern markets is a point happily in its favor. But in this respect it must compete in certain markets with the George's Creek basin and neighboring fields of Maryland that produce coal of about the same grade, and compete also with coals from the larger and more regular beds of the eastern portion of West Virginia. The Broad-Top field is, however, the farthest north-east of any of the semi-bituminous fields, its favorable relation to market, being shown in the small sketch map at the lower corner of the general geologic map.

The possibilities of extension in the undeveloped portions of the Broad-Top field offer additional opportunities for mining; but careful core-drilling in advance of mining should, in every case, be figured as a part of the necessary expenditures of development. In this way only can a proper knowledge be obtained of the best manner in which to take advantage of the haul and drainage in opening the mines. Natural outcrops and exposures are extremely rare over the field so that it is impossible for any geologist or engineer to obtain an accurate knowledge of local conditions from a study of the surface, or to judge the character of the coal beds at any great distance from opened mines or prospects. The nature of the weathering as related to structure is such that the surface is in most cases covered by débris and loose, angular, blocks of sandstone so that the ordinary method of prospecting by pick and shovel is slow, expensive, and unsatisfactory.

There is need for concentration of interests in the Broad-Top field. The problem encountered from one mine to another are often related in a manner that could best be handled by co-operation. A knowledge of the structure in one set of operations in many cases throws considerable light on what is to be expected in some adjacent development. Often an interchange of territory would be ad-

vantageous to neighboring workings, so that the problems of haulage and drainage could be handled more economically. Under co-operation, one general engineer could keep careful records of the advancement of all workings and by means of core-drilling with one good outfit could soon come into possession of such an advanced knowledge of the structure as to place the entire field on a basis of greater confidence and more healthy development. The field has strong competition to meet, and for this reason no union of interests could in any manner monopolize prices. The geographic position of the field entitles it to its natural advantages as related to market. One large concern in control of the entire field, or a pool of interest could not only place the coal on the market at a less cost, but what is even more important, they could take very large contracts and guarantee constant delivery.

It is estimated that an available railroad route from the East Broad-Top side of the field south via Hancock Maryland, will reach the Atlantic Coast near Baltimore at a distance of about two hundred miles.

A standard guage is at the present time being constructed from Markelsburg, on the Huntingdon and Broad-Top road, eastward along Trough creek, toward the east side of the coal field and it is reported that this line may push through to the Western Maryland road at Hancock.

INDEX

E.

F.

G.

H.

J.

K.

L.

M.

O.

P.

Q.

R.

S.

T.

W.

Z.